INVESTIGATIONS OF BULL TROUT (SALVELINUS CONFLUENTUS), STEELHEAD TROUT **(ONCORHYNCHUS MYKISS),** AND SPRING CHINOOK SALMON (0. **TSHAWYTSCHA)** INTERACTIONS IN SOUTHEAST WASHINGTON STREAMS

1991 Annual Report

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ABSTRACT

Bull trout (*Salvelinus confluentus*) are native to many tributaries of the Snake River in southeast Washington. The Washington Department of Wildlife (WDW) and the American Fisheries Society (AFS)' have identified bull trout as a species of special concern which means that they may become threatened or endangered by relatively. minor disturbances to their habitat (Williams et *al.* 1989).

Steelhead trout/rainbow trout' (*Oncorhynchus mykiss*) and spring chinook salmon (0. *tshawytscha*) are also native to several tributaries of the 'Snake River in southeast Washington. These species of migratory fishes are depressed, partially due to the construction of several dams on the lower Snake River. In response to decreased run size, large hatchery programs were initiated to produce 'juvenile steelhead and salmon to supplement repressed tributary stocks, a practice known as supplementationi

There is a concern that supplementing streams with. artificially high numbers of steelhead and salmon-'may have an impact on resident bull trout in these streams. Historically, these three species of fish existed together In 'large numbers, however, the amount of high-quafity habitat necessary for reproduction and rearing has been severely reduced in recent years, as compared to historic amounts.

The findings of the first year of a two year study aimed at identifying species interactions in southeast Washington streams are presented in this report. Data was collected to assess population dynamics; habitat utilization and preference, feeding habits, 'fish movement and migration, age, condition, growth, and the spawning requirements of bull trout in each of four streams. A comparison of the indices was then made between the study streams to determine if bull trout differ in the presence of the putative competitor species.

Bull trout populations were highest in the Tucannon River (supplemented stream), followed by Mill Creek (unsupplemented stream).

Young of the year bull trout utilized riffle and cascade habitat the most in all four streams. Juvenile bull trout utilized scour pool and run habitat the most in all four streams. YOY bull trout preferred plunge pool and scour pool habitat, as did juvenile bull trout in all four streams. These data show that while in the presence of the putative competitors, bull trout prefer the same habitat as in the absence of the putative competitors.

Juvenile bull trout preferred mayflies and stoneflies in Mill Creek, while in the presence of the competitor species they preferred caddisflies,

stoneflies, and Oligochaeta. It is felt that this difference is due to the differences in food items available and not species interactions: bull trout consume what is present.

Adult bull trout w&e difficult to capture, and 'therefore it was difficult to determine the migratory habits in the Tucannon River. It is recommended that future studies use radio telemetry to determine the migratory habitat of these fish.

The age, condition, and growth rates of bull trout differed only minimally between streams, indicating that if competitive interactions are occurring between these species it is not reflected by:

1) The length at age of bull trout;
2) The length-weight relationship of bull trout;. or,.
3) The rate of growth of bull trout.

The spawning habits of bull trout and spring chinook salmon are similar in the Tucannon River, however it was found that they spawn in different river locations. The salmon spawn below river kilometer 83, while 82% of bull trout spawn above that point. The peak of spawning for salmon occurred 10 days before the peak of bull trout spawning, indicating that very little competition for spawning locations occurs between these species in the Tucannon River.

Future species interactions study recommendations include, the use of electrofishing to enumerate bull trout populations, snorkeling to identify micro-habitat utilization, seasonal diet analysis, and radio transmitters to identify seasonal migration patterns of bull trout.

ACKNOWLEDGEMENTS

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1 .0 INTRODUCTION

Bull trout (*Salvelinus confluentus*) are native to many tributaries of the Snake River in southeast Washington. The Washington Department of Wildlife (WDW) and the American Fisheries Society (AFS) have identified bull trout as a species of special concern which means that they may become threatened or endangered by relatively minor disturbances to their habitat (Williams *et al. 1989)*

The bull trout is currently being considered for possible addition to the List of Endangered and Threatened Wildlife under the Endangered Species Act of 1973. Bull trout are now listed by the U.S. Fish and Wildlife Service as a Category 2 Species. Category 2 listing means that more biological. research and study is needed to determine the bull trout's status **(USDI 1989).**

Steelhead trout/rainbow trout (*Oncorhynchus mykiss*) and spring chinook salmon (*Oncorhynchus tshawytscha*) are also native to several tributaries of the Snake River in southeast Washington. These species of migratory fishes have been extirpated,, partially due to the construction of several dams on the lower Snake River.

In 1980 the United States Congress created the Northwest Power Planning Council to construct and initiate a recovery plan to recover the losses of these fish. NPPC set a goal to double the existing number of adult steelhead trout and salmon returning into the Columbia River and it's tributaries (Sheets 1984). Large hatchery programs were initiated to produce juvenile steelhead and salmon to supplement repressed tributary stocks.

There is -a concern that supplementing streams with artificially high numbers of steelhead and salmon may have an impact on resident bull trout in these streams. Historically, these three species of fish existed together in streams in large numbers, however, the amount of high-quality habitat necessary for reproduction and rearing has been severly reduced in recent years, as compared to historic amounts. These reductions can be attributed to timber removal, agriculture, cattle grazing, and recreational activities of man.

The concern arises about supplementing the current amount of habitat with the historically large numbers of fish that were produced in these streams. If the NPPC is to supplement the current habitat with enough juveniles to double the adult run size, the carrying capacity of the current habitat may be greatly exceded.

The final question is:

> Does supplementation, at current levels, have an impact on native bull trout populations in southeast Washington streams, and if not, at what level of supplementation will an impact be seen?

1.1 STUDY GOAL

The goal of this study is to determine if supplementation of stream stocks of steelhead trout and spring chinook- salmon in southeast Washington is having a negative impact on native bull trout.

W-e investigated bull trout and the anadromous species in four streams of southeast Washington. The four streams and ths species status were:

1) Control stream in which bull trout are the only species of interest present;

2) Bull trout are present and steelhead trout are supplemented;

3) Bull trout are present and it is supplemented with steelhead trout and spring chinook salmon; and,

4) Bull trout are present and the two anadromous species are not supplemented but reproduce naturally.

The objectives of this study were to:

1) Collect information on population dynamics, habitat use and preference, diet, age, condition, growth, and spawning requirements of bull trout; and,

2) Make comparisons of the above "indicies" among study streams and report shifts, similarities, *and* differences.

7.2 STUDY STREAM DESCRIPTIONS

The four study streams were (Figure 1 .2.1 .):

1) Mill Creek, an unsupplemented pristine tributary- to the Walla Walla River was used to describe the habitat and food preferences of bull trout without the effects of artificially high densities of hatchery-origin trout or salmon. Mill Creek serves *as* the watershed for the city of Walla Walla and human entrance into the watershed has been

prohibited since the early 1900's. Anadromous fish passage past the water intake dam (RK 22.2) was blocked until 1985, when an adult fish ladder was installed. In this study, Mill Creek refers to that portion of the river above the city of Walla Walla water intake dam.

2) Aaotin Creek, which currently supports a remnant population of native spring chinook salmon and a population of wild steelhead. Asotin Creek was supplemented with 33,000 hatchery steelhead smolts annually from 1983 until 1985, but is currently not supplemented (Schuck personal communication). Aaotin Creek was chosen because it supports a population of bull trout, and populations of steelhead trout and spring chinook salmon that reproduce naturally.

3) Wolf Fork, a tributary to the Touchet River,, which flows into the Walla Walla River, receives annual supplementation of 150,000 hatchery steelhead smolts. The Wolf Fork was chosen because it only has bull trout and steelhead trout. Therefore it represents a scenerio of moderate species interaction.

4) Tucannon River, which is annually supplemented with chinook salmon and steelhead trout: 150,000 and 160,000 respectively. The Tucannon River was chosen because it supports a population of bull trout and is supplemented with both species of interest. Species interaction may be high in this stream.

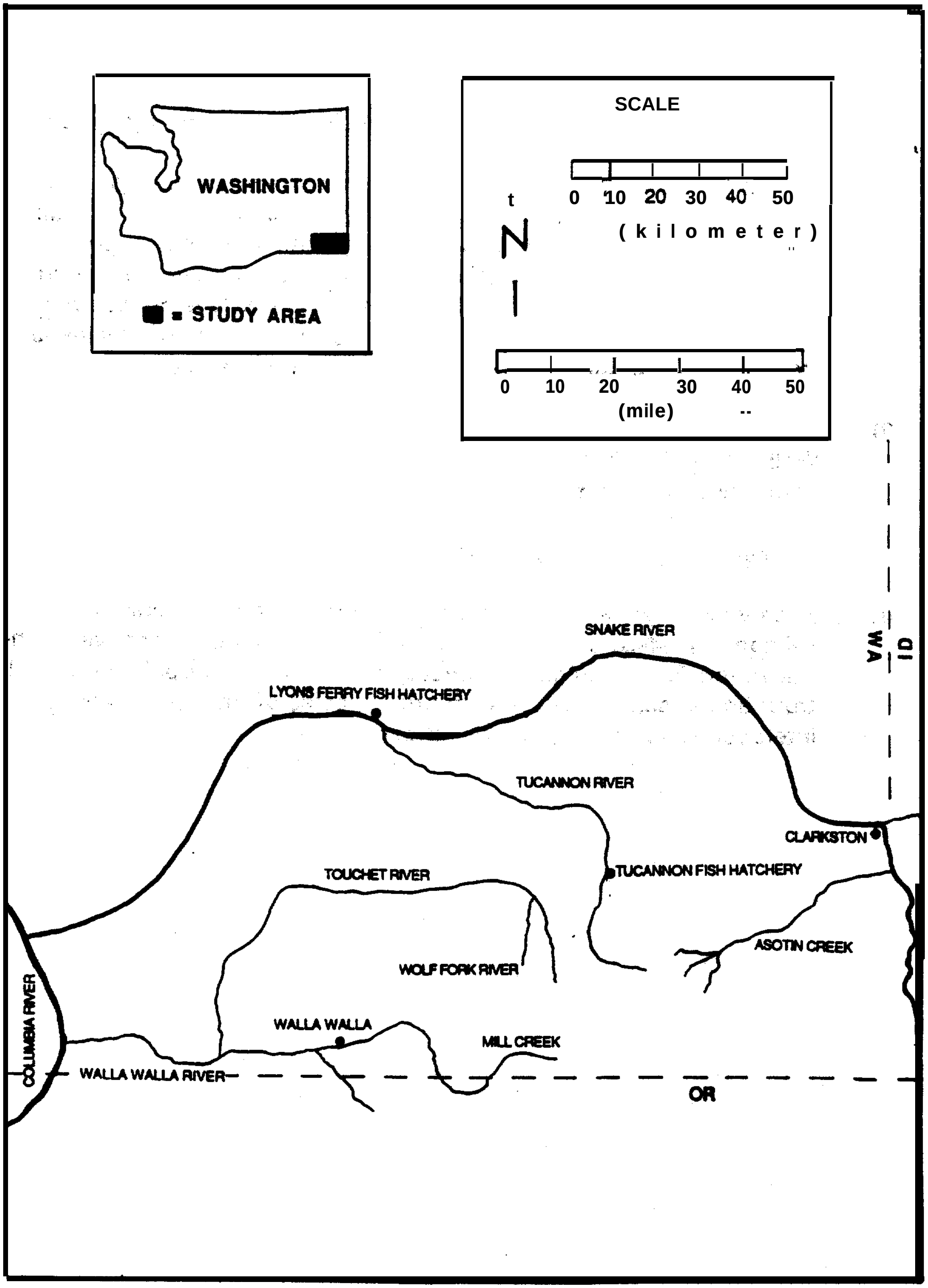

Figure 1.2.1 Map of southeast Washington showing location of study streams.

1.3 LOWER SNAKE RIVER COMPENSATION PLAN

In 1976 Congress authorized the Lower Snake River Compensation Plan as partial mitigation for the loss of Tucannon River spring chinook salmon and steelhead trout, as well as Snake River fall chinook salmon, and Touchet River steelhead trout. -Mitigation levels were set at 1 ,152 adult spring chinook salmon and 1,000 adult steelhead trout into the Tucannon River. One thousand five hundred and fifty steelhead trout into the Walla River (675 Touchet River), and 19,300 adult fall chinook salmon into the Snake River. This mitigation serves as partial compensation for the loss of several million salmon and steelhead, returning into subbasins of the Snake River, caused by 4 lower Snake River-dams: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite.

In 1980 Congress adopted the Northwest Power Act. This Act was developed principally in response to the regions electrical energy crisis. This legislation created the Northwest Power Planning Council (NPPC) and charged it with balancing. the need for power with fish and wildlife. The Act structured the Council as an interstate compact - composed of two members appointed by each of the governors of the four northwest states. In this way, Congress gave the states a central role in development of. the regions planning priorities. NPPC was authorized to develop the Columbia River Basin Fish and Wildlife Program. In the 1987 program, NPPC set an interim goal of doubling the number of salmon and steelhead returning to the Columbia River, annually (Sheets 1984).

After 8 years of, program operation steelhead run size into supplemented streams is currently greater than program goats while only limited success has been achieved with spring chinook salmon. It is not my objective to critically review tha programs, it is however, my concern that supplementation may behaving a negative impact on naturally produced salmon, steelhead, and non-anadromoua trout in the basin.

1.4 FISHERIES MANAGEMENT OF EACH OF THE STUDY STREAMS

1) Mill Creak, which produces no anadromous species; anadromoua fish passage past the water intake dam (RK 22.2) was blocked until 1985, when an adult fish ladder was installed. Species present include bull trout, steelhead trout, whitefish (*Prosopium williamsoni*), river lamprey (*Lampetra ayresi*) and sculpin (*Cottus sp.)*.

2) Asotin Creek, which currently supports a remnant population of native spring chinook salmon and a small population of wild steelhead. Asotin Creek was supplemented with 33,080 hatchery steelhead smolts annually from 1983 until 1985, but is currently not supplemented (Schuck personal communication). Asotin Creek may be supplemented with spring chinook salmon in future years but is currently not supplemented (Bugert personal communication). Harvest of adult steelhead is prohibited. However, anglers may harvest 2 rainbow trout over 30 cm (12 inches) long on the South Fork and in the North Fork above RK 19.2. Harvest of resident trout below the South Fork and RK 19.2 on the North Fork is timited to 8 trout. Species present include rainbow trout, spring chinook salmon, bull trout, steelhead trout, whitefish, river lamprey, sculpin, long nose dace (*Rhinichthus cataractae*), bridgelip sucker (*Catostomus columbianus*), and redside shiner (*Richardsonius balteatus*) (Bugert *et al.* 1988).

3) Wolf Fork, a tributary to the Touchet River, which flows into the Walla Walla River, receives annual supplementation of 150,000 hatchery steelhead smolts. These smolts are released in the Touchet River below the confluence of the Wolf Fork and Touchet River (Schuck et *al.* 1989). It is estimated that about 20% (9.9% to 32.8%) of tha steelhead smolts planted into the Touchet River residualize and a majority of those fish migrate into the Wolf Fork where they remain for 1 or more years (Viola et al. 1990). Also, thirteen thousand brown trout (*Salmo trutta*) are currently planted into the Touchet River above Waitsburg, Washington (RK 68.8) for a put-take fishery. A large percentage of the brown trout that are planted into the Touchet River are either harvested by sport anglers or move into the Wolf Fork River where they rear and spawn (Schuck personal communitadon, 1990). Chinook have bean extinct since the early 1900's (Bugert,WDF personal communicadon, 1990) but the river has been recognized as a potential location for reintroduction of spring chinook salmon if water flow problems could be corrected. The harvest of adult steelhead trout from the Touchet River is restricted to fish over 51 cm (20 inches) in length and of hatchery origin (adipose fin clip). Harvest of rainbow, brown, and bull trout in this river below the Wolf Fork Creek (RK 94.4) is limited to 8 fish daily. Harvest of these fish in the Wolf Fork, South Fork and in the North Fork above its confluence

with the Wolf Fork Is limited to a daily bag limit-of 2 fish over 30 cm (12 inches) in length. Species present in this river include rainbow trout, bull trout, steelhead trout, brown trout, whitefish, river lamprey, sculpin, longnose dace, bridgelip sucker, northern squawfish (*Ptychocheilus oregonensis*), and redside shiner.

4) Tucannon River, which is annually supplemented with chinook salmon and steelhead trout; 150,000 and 160,000 respectively. The harvest of adult steelhead trout from the Tucannon River is restricted to fish over 51 cm (20 inches) in length and of hatchery origin. Harvest of whitefish, rainbow, brown, and bull trout below the Little Tucannon River (RK 69.9) is limited to 8 fish daily. Harvest of whitefish, rainbow trout, brown trout, and bull trout in the Tucannon River above its confluence with the Little Tucannon River is limited to 2, fish over 30 cm (12 inches) in length. Harvest is prohibited in all tributaries to the Tucannon River. Species present include rainbow trout, spring chinook salmon, bull trout, steelhead trout, whitefish, river lamprey, sculpin, longnose dace, speckled dace, northern squawfish, and paemouth (*Mylocheilys caurinus*) (Bugert *et al.* 3 989).

2.0 MATERIALS AND METHODS

The goal of this study was to determine if supplementation of stream stocks of steelhead trout and spring chinook salmon in southeast Washington is having a negative impact on native bull trout.

To determine if there was an impact we collected information on population dynamics, habitat us8 and preference, diet , age, condition, growth, and spawning requirements of bull trout. We then made comparisons of the collected data between the control stream and the supplemented streams.

2.1 MATHEMATICAL IDENTIFICATION OF BULL TROUT

To be certain that we were dealing with bull trout, Haas's 1988 mathematical unweighted linear discriminant function was used to identify the orgamism. This formula differentiates bull trout and Dolly Varden (*Salvelinus malma*). This was important knowledge because Dolly Varden are mainly anadromous and much is known about their biology, while bull trout are strictly fluvial and little is known about their biology. Haas's mathematical formula is based on several meristic counts made on bull trout while in the field. The formula and methods for its use are reported in Appendix A.

2.2 HABITAT MEASUREMENTS

Habitat measurements were made of each stream to establish physical stream similarities and/or differences. This was important because fish populations, habitat use and preference, as well as condition, growth, and spawning requirement data may vary between stream, not because of species interactions but because the streams differ physically.
The habitat evaluation process began by obtaining U.S. Geological Survey Quadrangle maps (7.5 minute series) of the study area and measuring the study reach length of each stream. The study reach of each stream was determined by requesting Information from area fisheries biologists about the distribution of bull trout in each stream. This Information was confirmed by spot electrofishing each stream near the speculated downstream boundry. The study reach was then determined baaed on the presence of these fish in each river.

The study reach was then divided into six smaller reaches. A 100 meter. reach of stream was then chosen randomly within each of the 6 smaller reaches and marked by attaching a tin plaque to a tree adjacent to both the upstream and downstream end of the 100 meter segment (See figure 2.2.1. for an over-view of the study area and streams, see figures 2.2.2 through

2.2.5. for the study reach of each stream and habitat inventory segment location).

There appeared to be no widely accepted set of habitat definitions for small streams. Although riffles and pools are the basic units of channel morphology and will always develop in natural streams, however the actual configuration and hydraulic properties of these units are highly variable (Yang 1971). There are 12 different habitat types described in Bison (1981), as defined in the Glossary of Geology (Gary et al. 1974). After observation of each of the study reaches of each stream we determined that only 5 of the 12 habitat types described were encountered frequently enough in the study streams to warrant analysis.

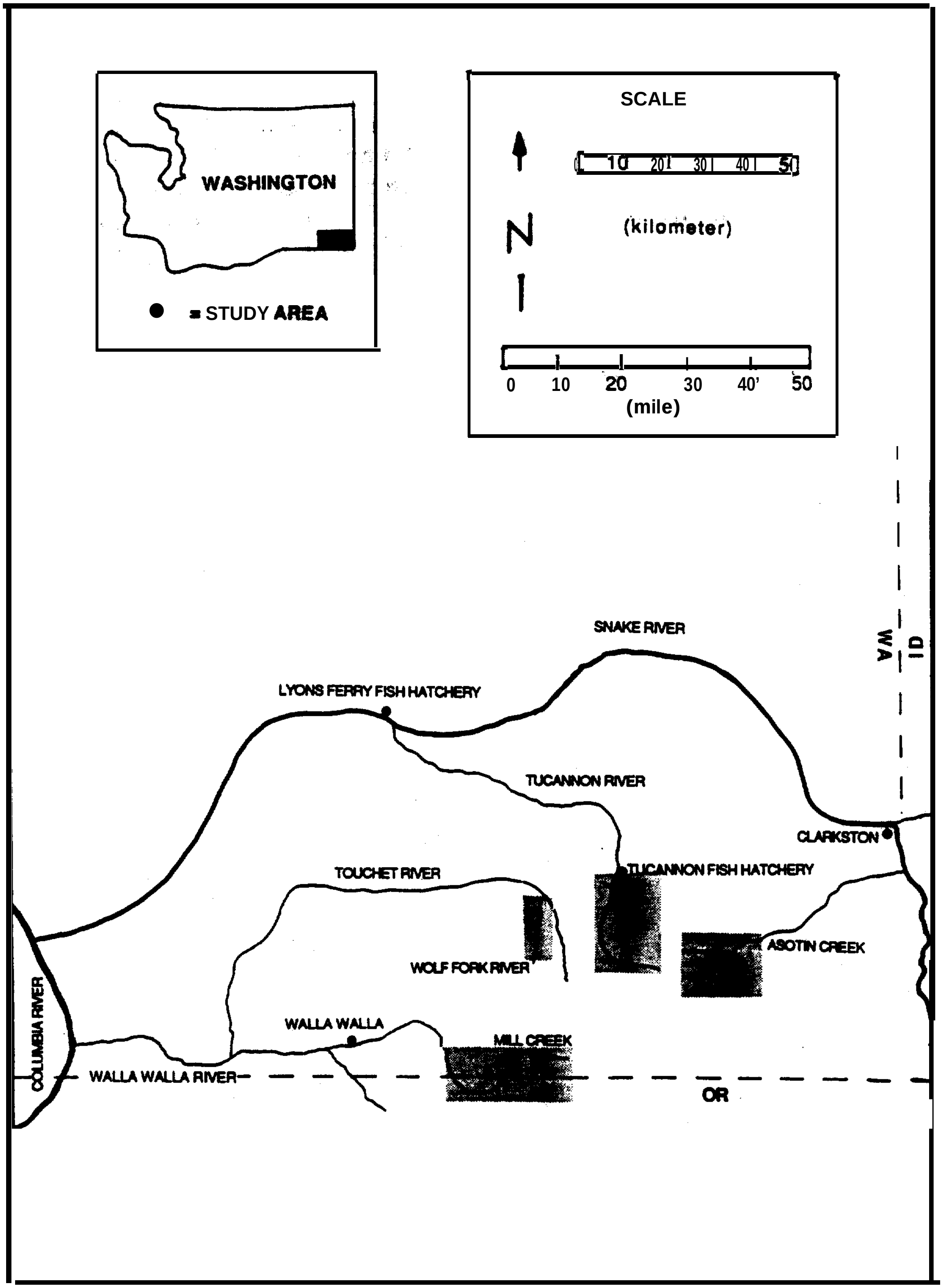

Figure 2.2.1. Map of southeast Washington showing location of study streams. Shaded regions indicate study reaches of each stream.

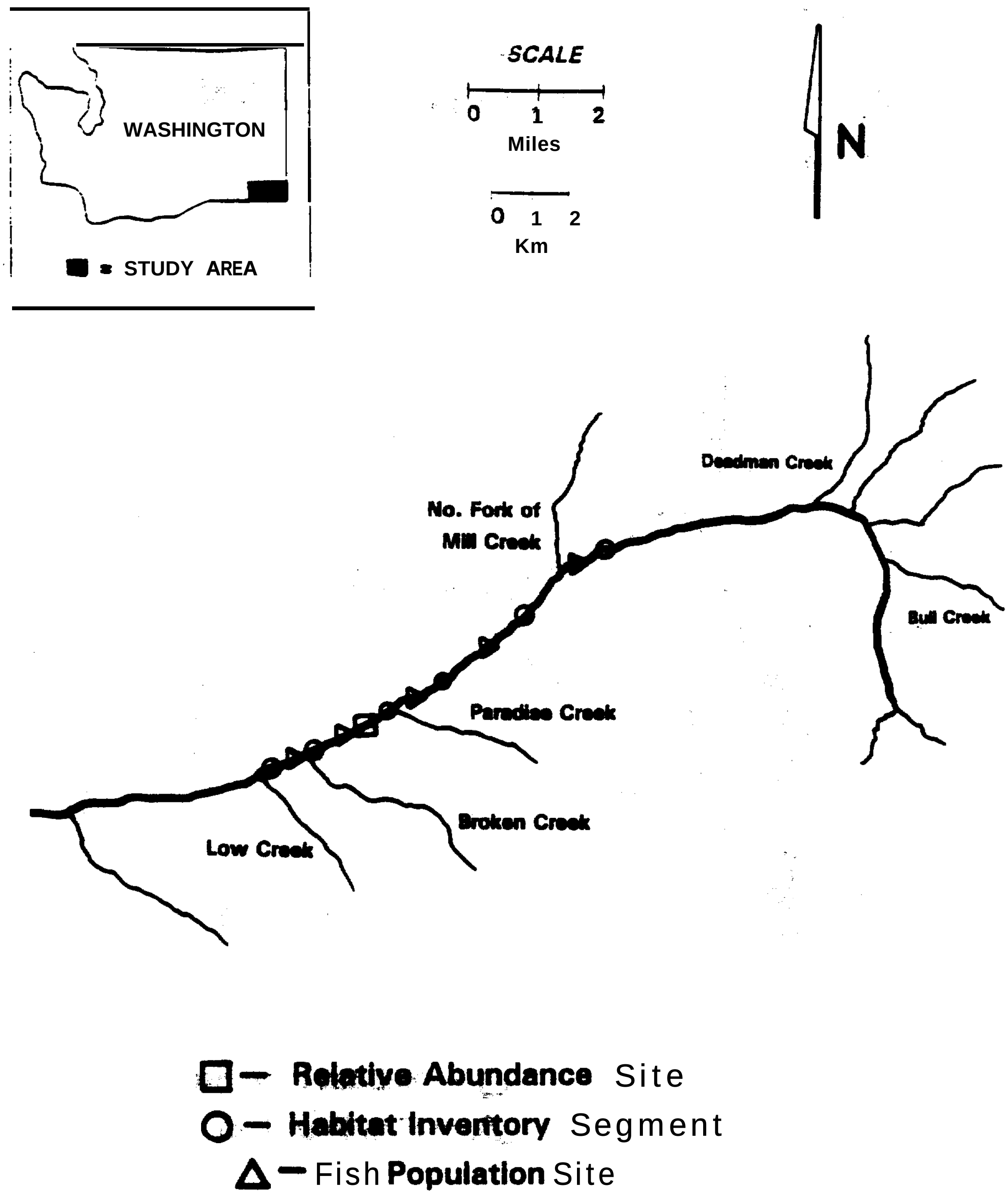

Figure 2.2.2. Relative abundance, habitat inventory, and fish population site location In Mill Creek, 1991.

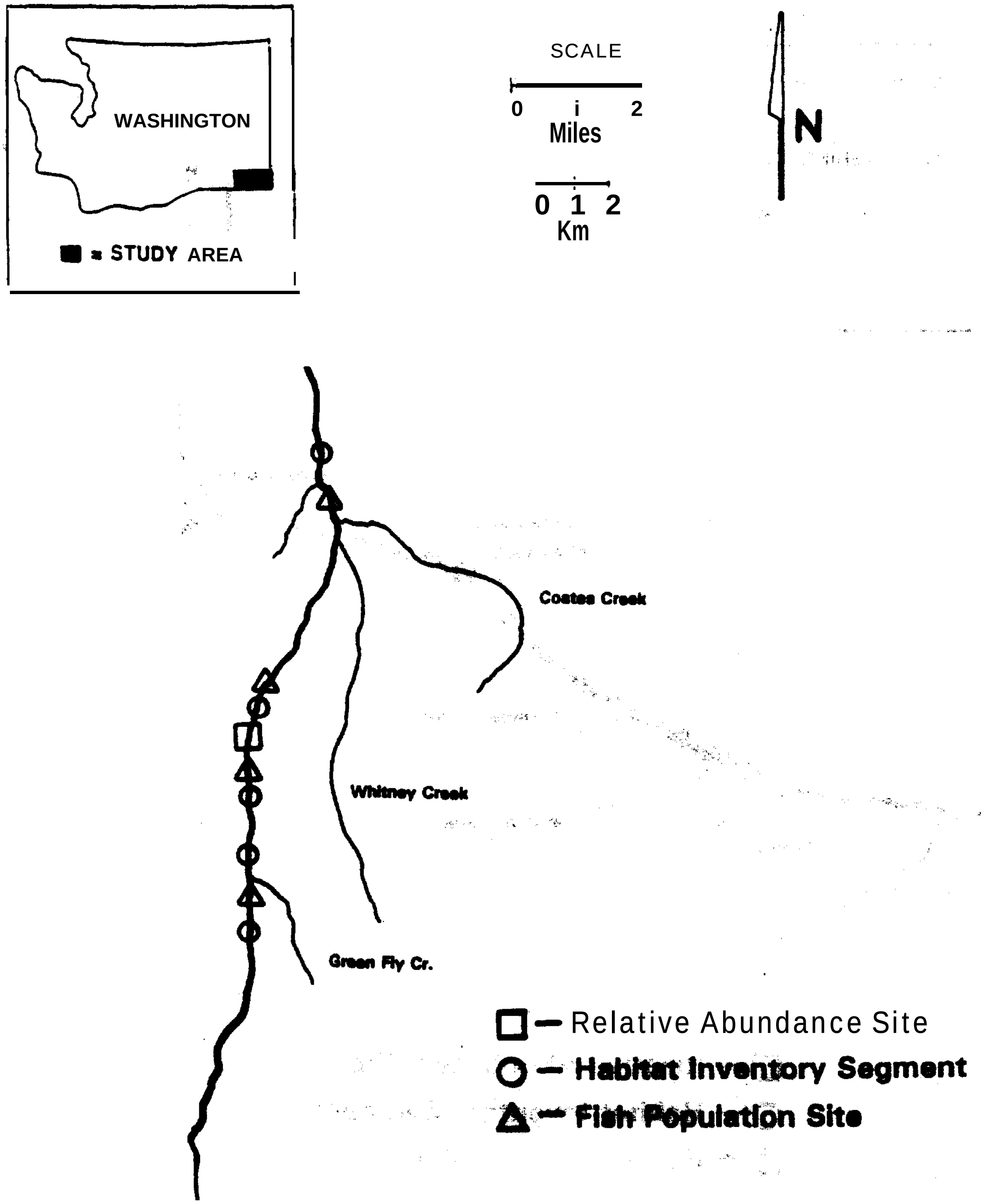

Figure 2.2.3. Relative abundance, habitat inventory, and fish population site location in the Wolf Fork, 1991.

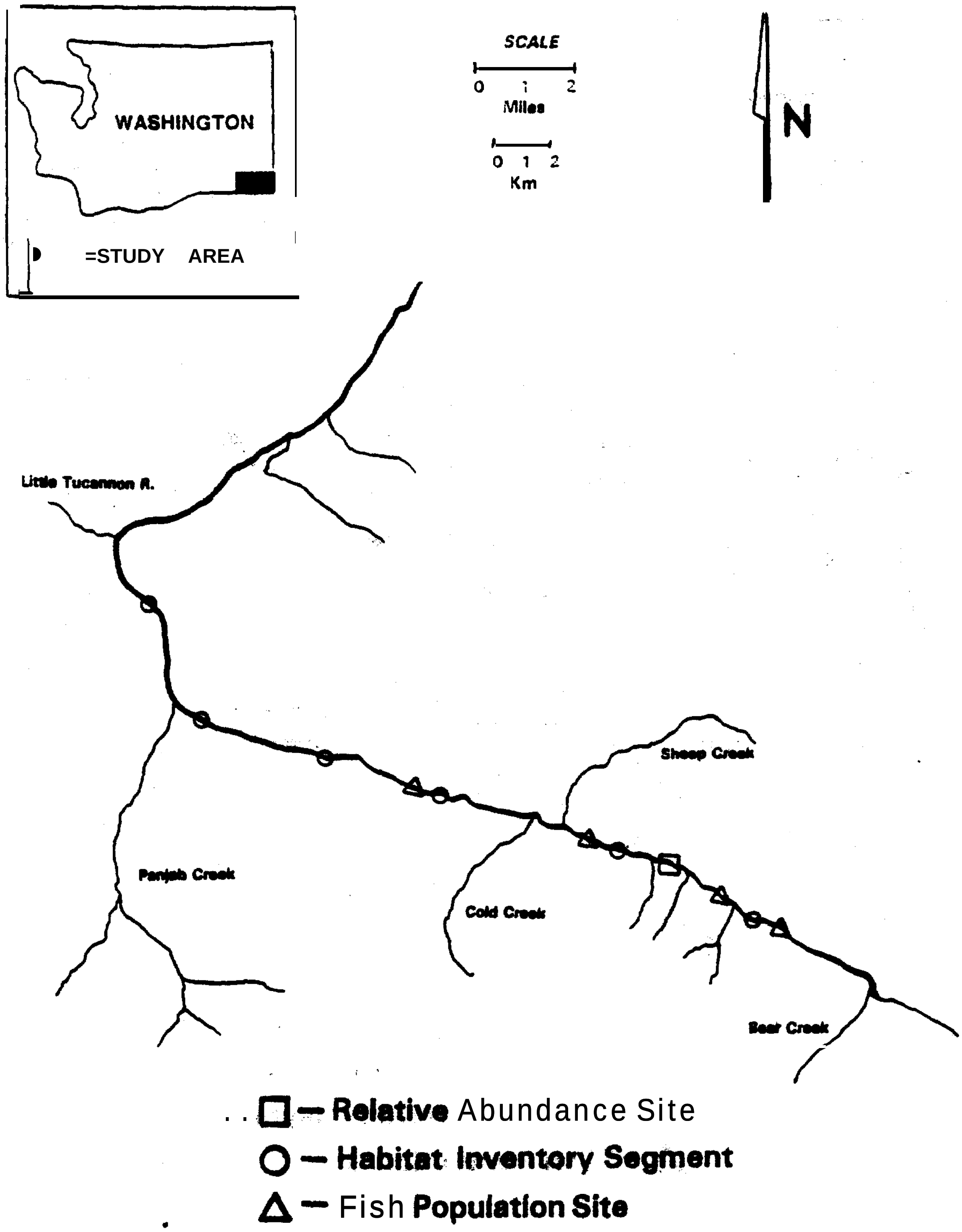

Figure 2.2.4. Relative abundance, habitat Inventory, **and fish population site** location in the **Tucannon River, 1991.**

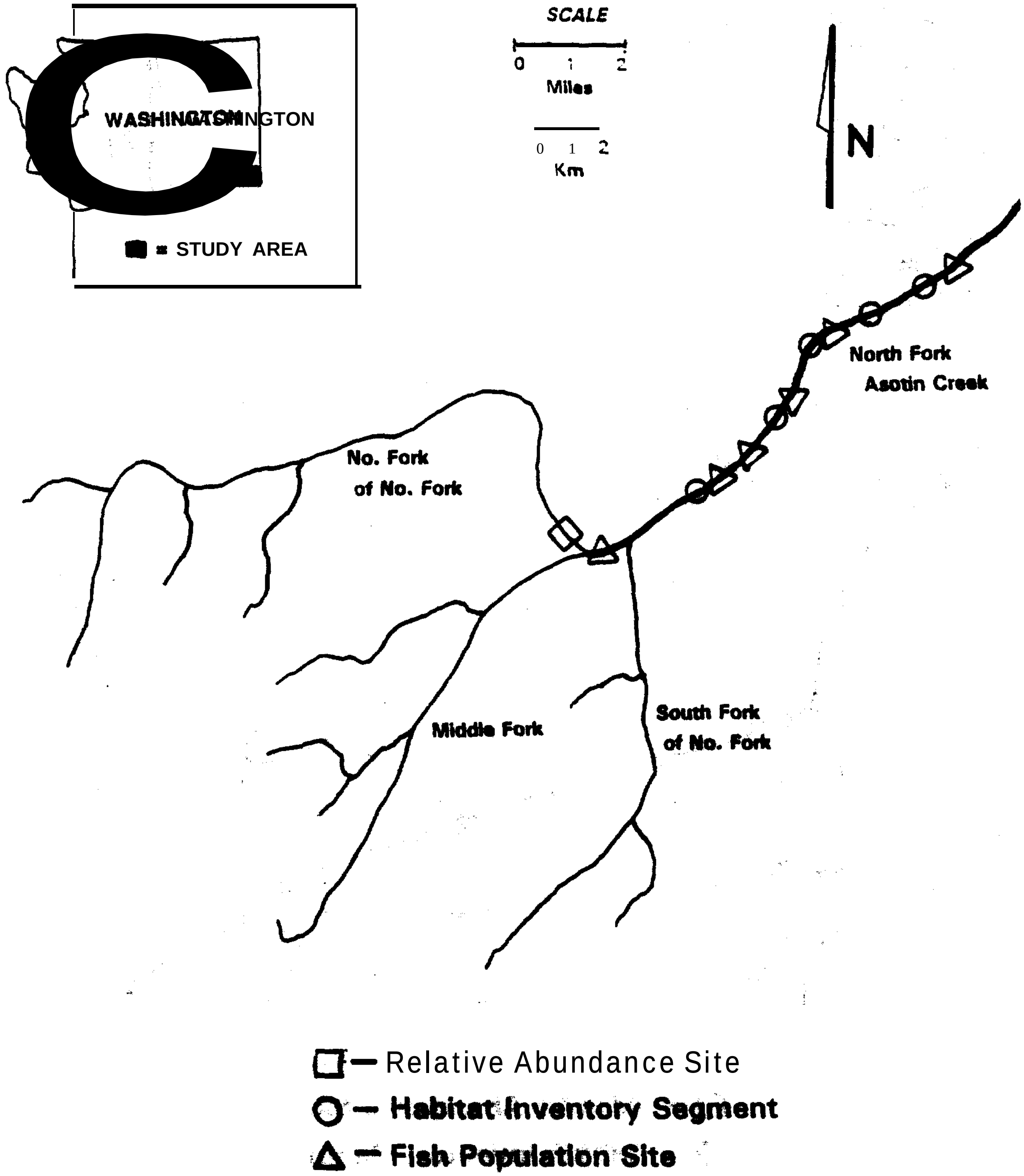

Figure 2.2.5. Relative abundance, habitat Inventory, and fish population site location in Asotin Creek, 1990 and 1991. The first six population sites located downstream (north) were surveyed in 1990, while the site located near the confluence of the Middle Fork was surveyed in 1991.

The five frequently encountered habitat types were 1) low gradient riffle, 2) cascade, 3) plunge pool, 4) scour pool, and 5) run. The scour pool category included lateral scour pools and trench pools.

The following information was collected at each segment:

1) Stream name;
2) date;
3) samplers;
4) stream temperature;
5) air temperature;
6) wetted width at 30 meter intervals;
7) bankful width at 30 meter intervals;
8) floodplain debris at 30 meter intervals;
9) gradient at 30 meter foot intervals: and
10) discharge (cubic feet and cubic meters per second).

As we progressed upstream through the segment the following was measured-and recorded for each individual habitat unit encountered:

1) Unit type (plunge pool, scour pool, run, riffle, cascade, or run):
2) width;
3) Length;
4) Depth;
5) Substrate composition which was *divided* into the following size classess:
   a) organic/silt < 1/8 "diameter
   b) small gravel 1/8 - 1/2" diameter
   c) large gravel 1/2 - 2 1/2 "diameter
   d) cobble 2 1/2 - 10"diameter
   e) boulder > 10"diameter
   f) bedrock;

6) overhead cover, expressed as a percent of the unit covered;
7) substrate embeddness, measured as a percentage of the surface area of boulders, -cobble or gravel covered by fines (sand or silt); and,
8) instream cover type (woody debris, boulder, undercut bank, or turbulence) and the percent of the unit that each of the instream cover types comprised.

Low gradient riffles were shallow (< 20 cm) stream reaches with moderate current velocity (20 - 50 cm/sec) and moderate turbulence. Cascades consisted of a series of small steps of alternating small waterfalls and shallow pools. Plunge pools occurred where the stream passed over a complete or nearly complete channel obstruction and dropped vertically into the streambed below, scouring out a depression. This pool type was often deep and possessed a complex flow pattern radiating from the point of water entry. Scour pools differed from plunge pools in that the Row was directed to one side of the stream 'by a partial channel obstruction. Often an undercut bank was associated with this pool type. Runs were characterized by moderately shallow water with an even flow that lacked turbulence. Runs had low gradient and no major flow obstructions (Bisson et al. 1981).

Gradient was determined by positioning an observer at a fixed location in the center of the stream. A second person walked 50 feet upstream and held a stadia rod. The observer then looked through a hand level and the level of the observer's eye was noted on the stadia rod. The observer rotated his head to the down stream direction, being careful not to change eye elevation. The second person then walked down stream 50 feet and the method was repeated. Gradient was determined to be the difference in height on the stadia rod divided by 100 feet.

Floodplain debris was reported as any permanent debris located in the floodplain that could be utilized by fish in the presence of high stream flow. It was recorded as a percentage of the floodplain covered with debris at the transect.

Discharge was determined at each segment that was inventoried. Discharge was determine by the method described in Section 2.16 Stream Flow Data.

This data was entered into an IBM compatible computer using Quattro Pro spreadsheet software. The following was then determined for each stream by habitat type:

1) total are8 by habitat type;
2) average and maximum depth:
3) substrate composition:
4) the amount of instream cover available; and
5) the amount of overhead cover.

All possible combinations of habitat types with their respective instream cover was analyzed. For instance, we determined the total amount of run habitat available in the study reach. We then determined the proportion of the total run habitat that had each instream cover type present (i e. 20% of the run had undercut banks). Because each electrofishing site was a simple habitat type with multiple instream cover types present, it was necessary to know the percentage of instream cover for each habitat type in the stream. This allowed for the comparison of electrofishing site habitat type and corresponding instream cover with the total available.

2.3 POPULATION ESTIMATES

Fish population of each species was determined for each site surveyed using the depletion method for population estimation of salmonids (Zippen 1958) and analyzed using the Burnham Maximum Likelihood method (VanDeventer and Platts 1983). The computer program FPSP-AL (Microfish), was utilized to determine the population estimate, variance, standard error,. and the upper and lower confidence intervals. This computer program model uses the successive depletion of catch sizes to estimate the actual population size by determining the likelihood of possible population sizes greater or equal to the total catch. The population size with the highest likelihood is considered the best estimate of the actual population size.

The population estimate and confidence intervals were converted into density values (fish/l 00m^2) for each site by dividing 100 by-the area sampled and multiplying by the population estimate. The confidence intervals were also converted in- the same manner. By multiplying the fish. density (fish/1 00m^2) for each habitat type by the total area of that habitat type, the standing crop of fish for each of the habitat types surveyed was determined. The total population estimate of fish (+ /- C.I.) for each habitat type was summed with the population estimate for all habitat types to yield 8 grand total estimate of the number of fish in each stream.

Total fish population estimates were determined by multiplying the average fish density for each habitat type by the amount of that habitat available in the study reach of each stream. These values were then added together to obtain a total population for the study reach of each stream.

Bull trout and steelhead trout populations were estimated in each of-the four study streams. Spring chinook salmon populations were estimated in the Tucannon River and Asotin Creek when encountered. Density values for each species of fish were determined using the depletion method for population estimation of salmonids (Zippen 1968) and analyzed using the Burnham Maximum-Likelihood method (Van Deventer and Platts 1983).

Population sites were located between the lowest point in each river and the highest point in each river (study reach), that contained bull trout, steelhead trout, and/or spring chinook salmon. Sites were evenly distributed within the study reach and included all five habitat types (plunge pool, scour pod, run, riffle, and cascade) that were analyzed in, the Habitat Inventory Section of this report. Site location in each stream is shown in Figures 2.2.2 through. 2.2.4. Sites were grouped into numbers of five (5 habitat types) and replicated four time8 throughout the study reach (tote! of 20 sites). Site number one was always located farthest upstream and site number 20 was always the farthest downstream site.

Fish collection and site habitat measurement procedures followed 5 steps: 1) the habitat site was blocked with nets and electrofished until a 70% reduction of the former pass was achieved; 2) fish were anesthetized, enumerated, weighed to 'the nearest 0.1 grams, and measured to the nearest millimeter; 3) site surface area was measured from one parallel and three perpendicular transects of the site: 4) measurements were collected along each transect for sits volume computation; and, 5) the type end amount Of instream and streambank cover was measured.

These instream end terrestrial cover measurements were made consistent with the methods used in section *2.2* - Habitat Measurements. This data was necessary to construct habitat preference curves, as described in Section 2.65- Habitat Utilization and Preference Analysis.

2.4 RELATIVE ABUNDANCE

Relative abundance information was collected by electrofishing a reach of each stream during stomach collection in the month of August (reach location is shown on maps of each Of the study streams, Figures 2.2.2. through 2.2.5).

Fish relative abundance was determined by using a Smith-Root Model 11-A backpack Electrofisher. Sampling consisted of one person doing the shocking and one person netting the fish. The "netter" carried a bucket in which the fish that were collected were placed for later enumeration and measurements. All fish of each species encountered were captured and enumerated. The reach selected in each stream was approximately two-thirds the distance from the upper most to the lower most portion of the stream that contained bull trout. As a result of intentional reach location, some of the population survey sites were located upstream of the relative abundance sites on each stream (Figure 2.2.2 through 2.2.5.). This allowed for the relative abundance data to be related directly to the area of the stream that the study was conducted in.

2.5 HABITAT UTILIZATION AND PREFERENCE

Habitat preference data were constructed for the macrohabitat types (run, riffle, scour pool, plunge pool, end cascade) for each life stage of each evaluation species. The macrohabitat preference information is presented as a bar graph with the most preferred habitat assigned 8 value of one. This technique assumes that individuals of a species will select areas Of the stream containing the most favorable combination of habitat variables (i.e., depth, substrate, instream cover, and overhead cover) and will utilize areas with less favorable conditions with decreasing frequency (Barber 1988).

In order to establish habitat preferences the quantity of available habitat and the corresponding fish utilization was determined. The physcial stream habitat was measured, as stated in section *2.2.* Habitat Measurement, while the corresponding fish utilization was determined, as stated in section *2.3* Population Estimates.

After completing the habitat measurements, the relative proportion each unit was of the total area was determined For instance, run type habitat made up 20% of the total area in 8 stream. We then determined fish densities by age class for each of the habitat types measured. By dividing percent use (% density for each life stage) by the percent availability 8 preference ratio for each age class for each habitat type was determined. The ratios were then normalized by dividing the preference ratios by the highest ratio, in order to set the highest ratio equal to one. All other preference values were then lees then one. By doing this, the highest preferred habitat type was determined and all other types were preferred by some value less than one.

2.6 FOOD AVAILABILITY

Three benthic macroinvertebrate samples were collected from each stream in July at the same time 88 stomach collection. Macroinvertebrate samples were collected from each stream in the area of highest overlap between the study species of interest, as determined by electrofishing surveys. The samples were collected from riffles at 1/4, 1/2, and 3/4 the distance across the riffle. The samples were collected using a modified Hess-Waters sampler (Hess 1941; Waters and Knapp I-961) with an aperature area of 0.1 m^2 and 390 *um* mesh size. We collected samples by pushing the sampler 10 cm into the substrate end disturbing the area within the sampler to 8 depth of *8* to 10 cm, (Hynes 1970; Williams and Hynes 1974). Orgsnisms within the sampler were displaced from rocks with a brush; the rocks were then removed.

Drift samples were not collected as it is well documented that bull trout feed primarily on fish and benthic organisms (McPhail and Murray 1 979; Pratt 1984; Armstrong and Morrow 1980). Steelhead trout and spring chinook salmon, as reported in the literature (Bugert 1989), feed on drifting as well as terrestrial invertebrates. The objective of the diet analysis and food production portion of this study was to determine competition between the specks, therefore, those organisms common to only one species' diet would provide no diet overlap information and were not evaluated.

Benthic organisms were preserved in 10 percent formalin and later transferred to 70 percent alcohol. Each sample was divided into eight equal portions using a sub-sampler. The organisms were sorted and identified to family using keys set by Merritt and Cummins (1984) and Pennak (1979).

Each family sample was dried in-an oven at 105°C. for 24 hours then weighed to 0.0001 grams, using a Mettler H-B balance, to obtain dry weight (Weber 1973).

Once the number and weight of each family of invertebrate was determined the densities per 0.1 m2 were determined. The relative abundance of each invertebrate family was then calculated. These data were combined with the numerical percentage obtained from the stomach analysis to determine 8 linear index of benthic food selection (Strauss 1979).

2.7 *FEEDING HABITS*

Due to a potential listing of Snake River spring chinook salmon on the Endangered Species List, no juvenile spring chinook salmon stomachs were collected; We used existing 1988 and 1989 spring chinook salmon diet information in the Tucannon River collected by WPF. In those studies WDF determined the frequency of occurrence, weight and number, index of relative importance,and eiecdvity index, for juvenile spring chinook salmon in the Tucannon River.

2.7.1 FIELD DATA COLLECTION FOR DIET ANALYSIS

Bull trout and steelhead trout were collected usng a Smith-Root Model 1 l-k backpack electrofisher. Fish were measured to the nearest millimeter using 8 metric measuring board. Ten samples of each species were collected from each stream during the *4th* week of July and again in the 6th week of August. Due to the possible listing of bull trout as threatened or endangered in Washington State, sample size was limited to 10 fish per month; 20 fish sacrificed in each stream for the study. Samples were collected from each stream In an area of highest species overlap es determined by electrofishing. Diet fluctuations due to age (i.e., size) were accounted for by sampling all age classess. Stomach lavage techniques were tried on three adult bull trout captured a the Tucanon River anadromous fish trap, but they failed to remove Cottidae (sp.) or Plecoptera. Ementics were not used, however their use may be useful with lavage techniques, to effectively remove these organisms.

Due to their reproductive i importance to the population,no more than1 adult-size bull -trout (> .3m) was collected from each stream at the time of stomach collection. However, one adult-size bull trout was collected from each site to determine if these large fish are predating on either steelhead trout, spring chinook salmon, sculpin, or juvenile bull trout.

In 1990 WDW collected eight adult bull trout from Mill Creek, two from the Tucannon River, and one from the Wolf Fork. This data will be reported along with the 1991 bull trout diet data in the feeding habits portion of this report. we realize that this will not provide definitive, or substantial information, however, we was bound by the species status and sampled accordingly. A comparison of the adult bull trout diet information collected will be made to the existing, published diet information.

The head and otoliths were removed from each bull trout and a scale sample was removed from each steelhead trout for age determination of fish according to procedures outlined in Section 2.9 - Age, of this report. The body cavity was opened for sex determination and stomach removal. The stomach was removed at the pyloric sphincter and the anterior portion of the esophagus and, placed in a jar containing a fixative of 10% formalin.

2.7.2 LABORATORY METHODS

In the laboratory, quantitative counts of the stomach contents (appendix E), of each species of fish were determined by identifying the. oranisms with a Bausch and Lomb Stereozoom 5 dissecting microscope using the keying sources of Merritt and Cummins (1984) and Pennak (1979). The organisma in the stomach were identified to the lowest taxonomic level possible. After the prey items were grouped to family they were counted and dry weights obtained by drying in an oven at 1 05°C for 24 hours and weighing on .a Sartorius model H51 balance (Weber 1973).

The number and. weight of each type of prey item found in the stomach contents of individual fish were entered into a computer file using Microsoft Excel on an IBM compatible computer. The program determined the mean and standard deviation of the number and weight of each prey category, the frequency of occurrence and the numerical and weight percentages of each type of prey item (Hynes 1950; Lagler 1956; Windell 1971; Bowen 1983).

2.7.3 INDEX OF RELATIVE IMPORTANCE

The index of relative importance (IRI; George and Hadley 1979), was used to indicate the relative contribution of each taxon of prey to fish and to identify prey items important to fish. This formula synthesizes occurrence, numerical frequencies, and weight frequencies into one number in order to compensate for the perceived biases of the individual indices. For instance, percent by weight may overestimate the importance of smaller organisms consumed in large numbers, while percent by weight may overestimate the importance of larger organisms.

The IRI was calculated using the formula:

$$RIa = \frac{100\ AIa}{\sum_{a=1}^{n} AIa}$$

where: RIa = relative importance of food item a,
AIa = absolute importance of food item a (i.e., frequency of occurrence + numerical frequency + weight frequency of food item a), and
n = number of different food types.

The relative importance index provides a useful indicator of the relative importance-of any one food item to the fish's diet. Relative importance values are 'percentages which range from 0 to 10096.

2.7.4 *DIET OVERLAP*

Diet overlap indices, described in Keast (1978), were calculated to determine if bull trout, steelhead trout, and spring chinook salmon compete for food items. A diet overlap may indicate competition if the food resources shared by the two species are limited MacArthur 1968). However, high diet overlap values could indicate a surplus of food, 'and that food is hot limiting. Therefore, available food resources were determined before an assessment of competition for food between bull trout and steelhead trout was made. Horn's (1966) index for diet overlap for these species was used with the estimate of benthic macroinvertebrate abundance to determine if a potential for competition exists.

Fish diet overlap values (Morisita 1969; Horn 1966) were based upon the IRI calculations. The overlap index is expressed in the equation:

$$Cx = \frac{\sum_{i=1}^{n}(Pxi \times Pyi)}{\sum_{i=1}^{n} Pxi^2 + \sum_{i=1}^{n} Pyi^2}$$

where: Cx = the overlap coefficient;
Pxi = the proportion of food category (i) in the diet of Species x;
Pyi = the proportion of food category (i) in the diet of species y; and
n = the number of food categories.

Overlap values range from 0 (no overlap) to 1 (complete overlap). Values of less than 0.3 are usually considered low and values greater than 0.7 indicate significant overlap (Peterson and Martin-Robichaud 1982).

2.7.5 ELECTIVITY INDEX

Benthic invertebrate density was the product of the number of organisms collected and the area sampled. Relative proportions of benthic macroinvertebrate density collected from Hess samples were combined with the numerical percentage obtained from the stomach analyses to determine a linear index Of invertebrate food selection (Strauss 1979):

$$L = Ri - Pi$$

where: L = the measure of food selection,
Ri = the relative abundance of prey (i) in the gut, and
Pi = the relative abundance of the same prey (i) in the environment.

Food selection values range from -1 to + 1. Values near, zero indicate the fish is selecting prey proportional to its abundance. Positive values indicate the fish is actively selecting the food item from the environment, while negative numbers indicate either, that the fish avoids the food item or the food item is inaccessible to the fish. This index was used to determine if bull trout and steelhead trout 'selectively prey on a particular taxa of invertebrates.

2.7.6. RANKING OF PREFERRED FOOD ITEMS

The four most numerous invertebrate taxa for each fish species were chosen as the preferred invertebrate prey; these taxa were determined by the frequency of occurrence, percent composition by number, percent composition by weight, and electivity index. Each prey item was allotted 3 points for scoring highest in a category, 2 points for second and 1 point for third. Points were totaled and prey items were ranked accordingly (Geist *et al.* 1988).

2.8 FISH MOVEMENT AN0 MIGRATION

An adult anadromous fish trap located at the Tucannon Fish Hatchery (RK 621 which is operated by WDF from March through June was used to trap upstream migrating bull trout. WDF personnel trapped and marked all bull trout that were captured. The trap is ideally located at the lower end of bull trout spawning grounds on the Tucannon River. Our initial intentions were to trap all fish moving in an upstream dlrection past the trap, measure and tag the fish, and release them above the trap. We then planned on observing these fish upstream from the trap throughout the summer by snorkeling, electrofishing, hook and line capture, or anglers returning tags.

2.9 AGE

Bull trout age, was determined by counting the hyaline growth, rings on the otoliths that were removed from each fish sacrificed for stomach collection. The hyaline zones were readily identified and enumerated by placing the otoliths in .a 'drop of water underneath a dissecting microscope and observing at 4 power with incident light. There was no way of validating the age as determined by this method, so repeated counts of each otolith were made. The otoliths were read 3 by three seperate persons.
The average percent error, coefficient of variation, and index of reproducibility for each fish aged was calculated to see if the determined age was reproducible, as described in Beamish and Fournier (1981).

Upon sacrificing the fish for stomach and'othoflth removal, the fork length, standard length, sex, location, date and other measurements were recorded necessary for identification of bull trout using Haas's (1988) formula. Otoliths were removed from the head as described by Peven (1990).

After the otoliths were removed they were placed into a vial containing glycerine' and a 'tag containing information about the fish (length, sex, 'date of capture 'and stream). The otoliths were read by placing them on a dark surface underneath a binocular dissecting microscope where they could be seen with either reflected or incident light. The dark-continuous hydina tone was assumed to be an annulus, while the white, opaque zone was considered summer growth (Bagenal and Tesch 1978; Chilton and Beamish 1982). Caution was used not to read the "metamorphic"check (the hyaline zone that occurs around the nucleus of the otolith at hatching) as an annulus (Peven 1990).

In order to make inter-stream comparisons of age, we used Beamish and Fournier's (1981) average percent error between readings method, index of average error, and Chang's (1982) coefficient of variation to compare age reproducibility between streams. A description, methods, dlscussion, and results of these indices is reported in appendix G.

2.7 7 CONDITION

Condition factors were 'computed as an indicator of the fishes general condition (Connell 1980; Everhart and Youngs 1975). The condition of a fish can be reduced if competitive interactions are occuring and therefore can provide evidence of competition (wooton 1990). Condition factors were calculated for all bull trout and steelhead trout collected in each stream and interstream comparisons of condition ware made. The formula to calculate the condition factor is:

$$K_{fl} = \frac{W}{L^3}(10)^5$$

Where: K_{fl} = condition factor;
W = weight of fish in grams; and
L = fork length of fish in millimeters.

The fork length of each fish collected in this study was measured because of the frequent and severe anomalies seen in the forks of the caudal fin of bull trout. These anomolies are speculated as being due to nipping by Other fish, digging with the caudal fin, or disease. Therefore, the condition of both bull trout and steelhead trout in terms of fork length, not total length is reported.

2.7 7 GROWTH

Measurements of growth as length quantify axial growth; measurements as weight quantify growth in bulk. These two categories of growth are usually highly correlated. But a fish can change in weight without changing in length, or vice versa (Wooton 1990). The relationship between length and weight is therefore an indication of the state of well-being of a fish and can be used to make inter-stream comparisons of general fish health. The weight and length was recorded for each bull trout and each steelhead trout collected from each stream at the time of capture during electrofishing surveys. Weight was regressed against length for juvenile (through their third year of growth) and adult (beyond. age *3)* for each stream to allow for inter-stream comparisons of growth, an indicator of possible competitive interactions (Wooton 1990).

2.12 SPAWNING GROUND SURVEYS

The number of redds, or nests constructed by bull trout in each stream was determined by walking the stream and visually identifying any redds. Identification was obvious, as bull trout spawn in the fall and periphyton is present on all undisturbed rocks. As the fish constructs tha redd it "digs" a depression in the gravel substrata and in doing so removes most of the periphyton and invertebrates attached. to the rocks used for tha radd.

The furthest upstream redd in each stream at each survey was located and its size and number was noted. The redds were, &numerated with a two digit number. The first of the digits represented the survey number. and the second number represented the number of the redd seen on that survey. The redds enumerated in a notebook and marked by hanging a biodegradable flag containing the 2 digit number on an adjacent tree so that the same radd would not be counted in subsequent surveys. The size of each radd was recorded in the notebook so that any additional construction on the redd, which may indicate redd overlap or disturbance, would be discamabla. The survey continued downstream until no further redds ware encountered.

2 . 7 3 REDD CHARACTERIZATION

In order to physically characterize bull trout redds and make interstream comparisons, the following physical characteristics of every third redd were measured in each stream:

1) Redd number
2) Adjacent water velocity
3) Water depth at
    a) bowl
    b) tail
    c) side
4) Substrate in the bowl and tail in the following class sizes
    a) < 1/8 "
    b) 1/8 - 1/2"

c) 1/2 - 2 1/2"
d) 2 1/2 - 10"

5) Habitat type
6) Proximity to the following cover types
a) deep water 1.30 cm)
b) overhanging terrestrial vegetation
c) large organic debris
d) undercut bank
e) turbulence

Water velocity (m/sec) was mesured with a Swoffer Modal 2100 Series open stream current velocity meter. Depth and distance measurements (meters) were determined by using either a taiascoping measuring rod or a tape measure.

Spring chinook salmon spawn in the fall of the year and competition between adult bull trout and salmon for spawning gravels could occur.. We reviewed recant annual, reports published by the Washington Department of Fisheries (WDF) for the 'Tucannon River to compare redd placement and habitat preferences of spring chinook salmon to bull trout in the Tucannon River.

2.74 STREAM TEMPERATURE DATA

To determine thermal regimes for each stream, continuous-reading thermographs ware deployed in both the Wolf Fork and Asotin Creek. WDF has maintained thermographs in the Tucannon River for the last 6 years and the City of Walla Walla has recorded stream temperatures in Mill Creek daily for the last several years.

The thermographs were deployed on 20 June and recorded stream temperatures continuously for 90 days, until 20 September. Locations of the thermographs in the Wolf Fork and Asodn Creak were at river kilometer (RK) 13.1 and at the Forest Service boundry fence (RK 34.1), respectively. The thermograph that was deployed on 9-July in the Wolf Fork malfunctioned and had to be repaired and re-deployed on 24-August and remained in the stream until 31 -October. WDF has a thermograph located at the downstream end of the bull trout range in the Tucannon River 300 meters below the confluence of Panjab Creek and the Tucannon River.

The thermograph was located at the city of Walla Walla water intake dam in Mill Creek which is at the downstream and of the bull trout range in that river. This data from each of these streams was recorded from 20-June to 31 -October. This data was used to report thermal differences in each stream and to allow evidence for stream similarities.

2.75 STREAM FLOW DATA

Stream flow was determined at each of the 6 habitat inventory segments discussed in section 2.12 Habitat Measurements. In 1991 Flow was taken on 6/27and 7/1 on the Tucannon River; 7/1 1 on Mill Creek; 7/1 6 on the Wolf Fork; and, 7/3 on Asodn Creek. flow was determined by measuring the width of the stream at the transact, dividing the width into 10 equal units, and recording the stream velocity and depth at each of these 10 units. The formula used to calculate flow, which is a modification of that reported for determining discharge from tha sum of flows for partial sections (Ralph 1990), was:

$$D = \sum_{i=1}^{n} \frac{tw}{n} (Vi)(di)$$

Where:
D = Discharge (cms or cfs)
n = the number of 'velocities taken ;
t W = the total stream width (m or ft);
Vi = the stream velocity (m/s or ft/sec); and
di = the stream depth (m or ft) .

3.0 RESULTS

3.1 MATHEMATICAL IDENTIFICATION OF BULL TROUT

Meristic information was collected from a total of 35 bull trout greater than 135 mm standard length (SL) in Mill Creek, 30 bull trout greater than 105 mm in the Tucannon River, and 14 bull trout greater than 124 mm in the Wolf Fork. AH fish were collected during either fish density sampling or stomach collection. Meristic information, as well as Haas's (1988) species differentiation formula and its methodology is presented in appendix A.

Table 3.1.1. contains species differentiation information about fish collected from the three study streams in which we found Dolly Varden/bull trout.

Two of the 35 assumed bull trout collected from Mill Creek ware Dolly Varden. Seven of the 30 assumed bull trout collected from the Tucannon River were Dolly Varden, and 0 of the 14 fish collected from the Wolf Fork were Dolly Varden.

Measurements of shorter fish resulted in negative values; the greatest standard length measurement of any fish showing a negative value was 169 mm. The average SL measurement of fish from all 4 streams showing a negative value was, 130.4 mm (range 98 - 169), while the average SL measurement of bull trout showing a positive value from all 4 streams was 191 mm (range 105-565).

Table 3.1.1. Results of bull trout/Dolly Varden differentiation function.

STREAM	AVG. VALUE	# OF FISH WITH VALUE < 0 (Dolly Varden)	# OF FISH WITH VALUE >0 (Bull trout)	AVG. STANDARD LENGTH OF FISH WITH VALUE < 0	AVG. STANDARD LENGTH OF FISH WITH VALUE < 0
Mill Creek	1.47	2	33	159	205
Wolf Fork	0.94	14	0	—	200
Tucannon	0.74	7	23	122	220

3.2 HABITAT MEASUREMENTS

A summary of the individual straam habitat inventory sections is presented in the following tables (3.2.2. through 3.2.5.) and gives the percentage of each of the measured characteristics associated with each habitat unit type.

The physical habitat measurement data collected from the study reach of' each stream showed that the four study streams were simillar in gradient, order, elevation, and percentage of each habitat unit type (Table 3.2.1.).

Substrate size and distribution among habitat unit types 'was similiar in all four streams, as would be expected in streams of similiar geological formation and age. As a result of habitat inventory segment location (see figures 2.2.2 through 2.2.5.) and historical land use, the percent of overhead cover varied within and between streams. Milt Creak, Wolf Fork, and the Tucannon River showed a conaistentaly high percentage of overhead cover for each habitat unit surveyed. However, Asotin Creek showed a consistently low percentage of overhead cover for each habitat unit surveyed.

Substrate embeddedness was low (0%) to moderate (O - 30%) in all streams and showed slight increases at downstream sites. The type and percent of instream-cover varied between habitat unit types but showed simillar variation between streams. Instream cover provided by turbulence and boulders was highest among cascades and riffles, while woody debris was highest among plunge pools.

Table 3.2.1. **Interstream comparison** of **gradient, stream order, elevation, and percentage** of **each habitat** unit **type.**

RIVER	Gradient	Stream Order	Elevation (Meters)	HABITAT UNIT TYPE Plunge Pool	Scour Pool	Run	Riffle	Cascade
Mill Cr.	3.1%	2	730-890	0.9%	3.9%	35.8%	30.2%	32.0%
Wolf Fork	3.6%	2	820-960	5.5%	0.3%	19.7%	55.3%	19.2%
Tucannon R.	3.2%	2	900-1150	7.0%	2.9%	42.0%	37.2%	11.0%
Asotin Cr.	2.5%	2	750-960	2.6%	0.7%	33.8%	49.9%	28.1%

Table 3.2.2. **Contribution** of **physical** parameters **to each habitat unit** type **surveyed** in **Mill Creek, 1991**.

PARAMETER	HABITAT UNIT TYPES				
	PLUNGE POOL	*SCOUR POOL*	*RUN*	*RIFFLE*	*CASCADE*
SAMPLE SIZE:	n = 8	n = 7	n = 30	n = 21	n = 23
'AVERAGE SIZE (m2):	4.4	39.1	49.4	71.4	68.5
AVERAGE DEPTH (MAX.):	.38 (.51)	.50 (.86)	0.31	0.24	0.29
. ACTUAL TOTAL AREA (m2)	268.4	1,138.0	10,455.1	8,821.0	9,343.3
% OF TOTAL AREA:	.92%	3.90%	35.83%	30.23%	32.02%

PERCENT OF HABITAT UNITS THAT CONTAJNED EACH SUBSTATE CLASS

(Organic): '1	0%	0%	0%	0%	0%
(Fines < 2 mm): 2	0%	0%	2%	0%	0%
(Gravel 2 mm - 6 cm): 3	13%	50%	13%	21%	2%
(Cobble 6 cm - 25 cm): 4	50%	14%	65%	58%	20%
(Boulder < 25 cm): 5	13%	36%	20%	21%	78%
(Bedrock) 6	13%	0%	0%	0%	0%

PERCENT OF HABITAT UNITS THAT CONTAINED EACH OVERHEAD COVER CATAGORY

(No cover): 0	0%	14%	10%	5%	0%
(x < 30% cover): 1	25%	29%	3%	14%	13%
(30% < x < 70% site covered): 2	75%	1.4%	27%	38%	39%
(x > 70% site covered): 3	0%	43%	80%	43%	48%

AVERAGE SUBSTRATE EMBEDDEDNESS FOR EACH HABITAT UNIT TYPE

(Unembedded): 1	100%	71%	97%	100%	100%
(< 30% unembedded): 2	0%	29%	3%	0%	'0%
(> 30 % embedded):	0%	0%	0%	0%	0%

PERCENT OF HABITAT UNITS THAT CONTAINED THE INSTREAM-COVER TYPES

(Woody debris): 1	50%	71%	73%	19%	48%
(Boulder): 2	38%.	29%	43%	72%	83%
(Undercut bank): 3	25%	43%	37%	14%	26%
(Turbulence): 4	75%	29%	17%	99%	100%

OF THOSE SITES THAT HAD INS-I-REAM COVER THIS IS THE AVERAGE % FOUND IN EACH HABITAT UNIT TYPE

(Woody debris): 1	25%	21%	22%	9%	8%
(Boulder): 2	8%	7%	10%	19%	26%
(Undercut bank): 3	13%	9%	90%	3%	6%
(Turbulence): 4	30%	6%	3%	22%	39%

Table 3.2.3. Contribution of tha listed physical parameters to each . habitat type surveyed In the Wolf Fork, 1991.

PARAMETER	HABITAT UNIT TYPES				
	PLUNGE POOL	*SCOUR POOL*	*RUN*	*RIFFLE*	*CASCADE*
SAMPLE SIZE:	n = 13	n = 2	n = 21	n = 29	fp
AVERAGE SIZE (m2):	12.8	1.8	28.1	63.2	55.7
AVERAGE DEPTH (MAX.):	.41 (.64)	.35 (.43)	0.34	0.22	0.3
ACTUAL TOTAL AREA (m2)	1,556.8	90.2	5,564.4	15,587.7	5,406.5
% OF TOTAL AREA:	5.2%	0.3%	19.7%	55.3%	19.2%

PERCENT OF HABITAT UNITS THAT CONTAINED EACH SUBSTRATE CLASS

(Organic): 1	8%	0%	0%	0%	0%
(Fines < 2 mm): 2	0%	25%	2%	0%	0%
(Gravel 2 mm - 6 cm): 3	31%	50%	14%	7%	0%
(Cobble 6 cm - 25 cm): 4	23%	25%	60%	35%	11%
(Boulder < 25 cm): 5	46%	0%	26%	55%	89%

PERCENT OF HABITAT UNITS THAT CONTAINED EACH OVERHEAD COVER CATAGORY

(No cover): 0	39%	50%	5%	14%	22%
(x <30% cover): 1	23%	0%	0%	17%	22%
(30% < x < 70% site covered): 2	23%	0%	24%	24%	33%
(x >70% site covered): 3	15%	50%	71%	35%	22%

AVERAGE SUBSTRATE EMBEDDEDNESS FOR EACH HABITAT UNIT TYPE

(Unembedded): 0	85%	50%	91%	98%	100%
(< 30% unembedded): 1	15%	50%	10%	3%	0%
(> 30 % embedded): 2	0%	0%	0%	0%	0%

PERCENT OF HABITAT UNITS THAT CONTAINED THE INSTREAM COVER TYPES

(Woody debris): 1	46%	50%	33%	17%	0%
(Boulder): 2	38%	50%	67%	83%	100%
(Undercut bank): 3	31%	0%	10%	14%	0%
(Turbulence): 4	46%	0%	43%	90%	100%

OF THOSE SITES THAT HAD INSTREAM COVER, THIS IS THE AVERAGE % FOUND IN EACH HABITAT TYPE

(Woody debris): 1	40%	10%	32%	26%	0%
(Boulder): 2	18%	30%	30%	28%	54%
(Undercut bank): 3	40%	0%	20%	20%	0%
(Turbulence): 4	30%	0%	26%	28%	33%

Table 3.3.4. Contribution of the listed physical parameters to each habitat type surveyed in the Tucannon River, 1991.

HABITAT UNIT TYPES

PARAMETER	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
SAMPLE SIZE:	n = 15	n = 6	n = 31	n = 27	n = 14
AVERAGE SIZE (m2):	11.4	17.6	73.8	73	45.1
AVERAGE DEPTH (MAX.):	.72 (1.1)	.81 (.85)	0.37	0.27	0.48
ACTUAL TOTAL AREA (m2)	8,329.8	2,668.5	38,206.7	33,880.5	10,000.2
% OF TOTAL AREA:	6.95%	2.93%	41.95%	37.20%	10.98%

PERCENT OF HABITAT UNITS THAT CONTAINED EACH SUBSTRATE CLASS

	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
(Organic): 1	10%	8%	2%	4%	8%
(Fines < 2 mm): 2	40%	33%	5%	5%	8%
(Gravel 2 mm - 6 cm): 3	23%	42%	34%	34%	26%
(Cobble 6 cm - 25 cm): 4	7%	0%	41%	21%	8%
(Boulder < 25 cm): 5	20%	17%	18%	37%	50%

PERCENT OF HABITAT UNITS THAT CONTAIN ED. EACH OVERHEAD COVER CATAGORY

	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
(No cover): 0	20%	17%	23%	33%	29%
(x < 30% cover): 1	13%	17%	32%	15%	29%
(30% < x c 70% site covered): 2	27%	13%	23%	26%	7%
(x > 70% site covered): 3	40%	33%	23%	26%	36%

AVERAGE SUBSTRATE EMBEDDEDNESS FOR EACH HABITAT UNIT TYPE

	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
(Unembedded): 0	80%	66%	100%	100%	100%
(< 30% unembedded): 1	13%	17%	0%	0%	0%
(> 30 % embedded):- 2	7%	17%	0%	0%	0%

PERCENT OF HABITAT UNITS THAT CONTAINED THE INSTREAM COVER TYPES

	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
(Woody debris): 1	100%	83%	94%	67%	79%
(Boulder): 2	0%	0%	6%	11%	29%
(Undercut bank): 3	0%	0%	10%	11%	0%
(Turbulence): 4	60%	0%	23%	71%	100%

OF THOSE SITES THAT HAD INSTREAM COVER, THIS IS THE AVERAGE % FOUND IN EACH HABITAT TYPE

	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
(Woody debris): 1	55%	38%	33%	18%	44%
(Boulder): 2	0%	0%	1%	6%	5%
(Undercut bank): 3	0%	[illegible]	2%	2%	0%
(Turbulence): 4	21%	0%	3%	17%	41%

Table 3.25. Contribution of the listed physical parameters to each habitat type surveyed in Asotin Creek, 1991.

HABITAT UNIT TYPES

PARAMETER	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
SAMPLE SIZE:	n = 15	n = 2	n = 27	n = 27	n = 13
AVERAGE SIZE (m2):	6.81	19.2	47.69	67.2	44
AVERAGE DEPTH (MAX.):	0.43 (0.65)	0.48 (1.1)	0.3	0.19	0.26
ACTUAL TOTAL AREA (m2)	102.1	38.4	1,430.6	1,814.4	572.5
% OF TOTAL AREA:	3.%	01.%	36.%	46.%	14.%
PERCENT OF HABITAT UNITS THAT CONTAINED EACH SUBSTRATE CLASS					
(Organic): 1	0%	0%	0%	0%	0%
(Fines < 2 mm): 2	23%	0%	2%	0%	0%
(Gravel 2 mm - 6 cm): 3	13%	0%	21%	11%	0%
(Cobble 6 cm - 25 cm): 4	23%	50%	69%	63%	88%
(Boulder < 25 cm): 5	40%	50%	8%	26%	12%
PERCENT OF HABITAT UNITS THAT CONTAINED EACH OVERHEAD COVER CATAGORY					
(No cover): 0	33%	50%	30%	56%	62%
(x < 30% cover): 1	20%	50%	26%	22%	31%
(30% < x < 70% site covered): 2	20%	0%	26%	26%	0%
(x > 70% site covered): 3	27%	0%	19%	4%	7%
AVERAGE SUBSTRATE EMBEDDEDNESS FOR EACH HABITAT UNIT TYPE					
(Unembedded): 0	47%	100%	70%	97%	100%
(< 30% unembedded): 1	53%	0%	30%	3%	0%
(> 30 % embedded): 2	0%	0%	0%	0%	0%
PERCENT OF HABITAT UNITS THAT CONTAINED THE INSTREAM COVER TYPES					
(Woody debris): 1	93%	100%	89%	85%	31%
(Boulder): 2	13%	0%	15%	30%	92%
(Undercut bank): 3	7%	0%	41%	7%	0%
(Turbulence): 4	40%	100%	19%	48%	100%
OF THOSE SITES THAT HAD INSTREAM COVER, THIS IS THE AVERAGE % FOUND IN EACH HABITAT TYPE					
(Woody debris): 1	38%	35%	30%	21%	35%
(Boulder): 2	20%	0%	15%	20%	28%
(Undercut bank): 3	20%	0%	20%	30%	0%
(Turbulence): 4	20%	20%	20%	25%	29%

3.3 POPULATION ESTIMATES

Site specific fish population, 'density and confidence intervals (+ /-) , for each age class and species is reported in Appendix B. Table 3.3.1. shows the population estimates and 95% confidence intervals for each species and age class of fish sampled in each stream in 1991. Table 3.3.2. shows the density of each species and-age class of fish for each of the study streams so that inter-stream comparisons could be made.

It was assumed in the population estimates, that only rainbow trout exist in Mill Creek as no adult steelhead have been observed ascending the water intake dam or spawning in this river above the water intake dam. Therefore, populations of *O. Mykiss* will be reported as rainbow trout in Mill Creek throughout this report.

Table 3.3.1. Population estimates and 95% confidence intervals for each species and age class for each stream sampled in 1991.

RIVER	Y-O-Y BULL TROUT	+ /- C.I.	JUVENILE BULL TROUT	+ /- C.I.	Y-O-Y STEELHEAD	+ /- C.I.	JUVENILE STEELHEAD	+ /- C.I.
Mill Creek	1,754	61.9	2,171	21.8	1,164	153.8	1,036	57.86
Wolf Fork	1,844	118.8	1,066	137.2	1,967	71.2	1,336	541.6
Tucannon R.	3,624	336.1	1,329	38.1	1,953	885.1	3,822	914.9
Asotin Cr.	0	0	284	0	17,766	0	9,645	0

Table 3.3.2. Species density (#/100m^2) for each age class in each of the study streams, 1991.

RIVER	AREA SURVEYED(m^2)	B.T. YOY DENSITY	B.T. JUV. DENSITY	STHD YOY DENSITY	STHD JUV. DENSITY
Mill Cr.	29,179.7	6.0	7.4	4.0	3.6
Wolf Fork	28,202.8	5.6	3.7	6.9	4.7
Tucannon R.	91,076.7	3.9	1.6	2.1	4.2
Asotin Cr.	67,277.8	0	0	28.5	14.3

Young of the year bull trout densities varied between habitat types and rivers but were on the average higher in turbulent water and lower in placid water for all 3 streams (Table 3.3.3.). There was a decrease from an average of 7.1 /100m^2 young of the year bull trout in the upper-most sites to 0/100m^2 in the lower sites in each stream (Appendix B).

Juvenile bull trout densities were similiar between habitat types for all streams except Asotin Creek (Table 3.3.4.). The 1 .5 fish/100m^2 reported for Asotin Creek is based on one 163 mm bull trout that was captured in a 64 m^2 cascade; no. other bull trout were captured in Asotin Creak, 1991.

Young of the year stealhead trout densities varied between habitat types and rivers but were on the average higher in placid water and lower in more turbulent water for all 4 streams (Table 3.3.5.). YOY steelhead trout densities were exceptionally high in Asotin Creek as compared to the other 3 study streams due to sample size; only 1 site of each habitat type was surveyed in Asotin Creek, while 4 sites of each habitat type were surveyed in the other streams.

Juvenile steelhead trout densities varied between habitat types and streams but were higher on the average in placid water and lower in more turbulent water in all four streams (Table 3.3.6.). Juvenile steelhead trout densities were exceptionaly high in Asotln Creak, which may be due to low sample size, a6 stated above.

Table 3.3.3. Y-O-Y bull trout densities (#/100m²) for each habitat type.

RIVER	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
Mill Creek	1.9	3.9	3.3	8.8	8.1
Wolf Fork	1.6	0	3.2	3.4	1.5
Tucannon R.	4.4	6.7	3.0	3.8	7.4
Asotin Cr.	0	0	0	0	0

Table 3.3.4. Juvenile bull trout densities (#/100m²) for each habitat type.

RIVER	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
Mill Creek	8.7	6.8	8.4	7.7	6.5
Wolf Fork	2.6	6.5	2.3	2.2	2.0
Tucannon R.	1.3	4.6	1.8	1.4	7.4
Asotin Cr.	0	0	0	0	1.5

Table 3.3.5. Y-O-Y steelhead trout densities (#/100m^2) for each habitat type.

RIVER	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
Mill Creek	5.8	3.0	2.4	4.8	3.0
Wolf Fork	0.8	10.4	3.0	3.0	2.5
Tucannon R.	4.0	4.3	1.8	1.6	1.9
Asotin Cr.	41.4	4.2	30.0	20.8	18.0

Table 3.3.6. Juvenile steelhead trout densities (#/100m^2) for each habitat type.

RIVER	PLUNGE POOL	SCOUR POOL	RUN	RIFFLE	CASCADE
Mill Creek	7.6	10.9	35.2	3.4	2.0
Wolf Fork	1.0	10.4	3.0	3.0	2.5
Tucannon R.	16.0	5.7	4.4	2.3	2.6
Asotin Cr.	27.6	16.7	8.9	2.6	7.5

3.4 RELATIVE ABUNDANCE

Tables 3.4.1. through 3.4.4. report the total number of fish caught, fish density (#/100m^2), relative abundance (Rla), and the area sampled for each species of fish caught in each river in August; 1991. Sculpins were the most abundant species present in Mill Creek and Asotin Creek.. Steelhead trout were the most abundant species in the Wolf Fork and the 'Tucannon River.

Bull trout density, as determined during relative abundance surveys, was highest in the Tucannon River (0.02/100m^2) and lowest in Asotin Creek (0/100m^2). The area of stream sampled varied between streams because we were collecting bull trout and steelhead trout stomachs to meet the stomach collection objectives of 'the feeding habits portion of the study, therefore we continued sampling until we collected a minimum of 10 stomachs of each species.

Table 3.4.1. Total number, density, and relative abundance of each species caught during relative abundance surveys on Mill Creak.

SPECIES	# CAPTURED::	DENSITY (#/100m²)	Rla	AREA SAMPLED (m²)
Bull Trout	10	0.008	0.05	1,224
Rainbow Trout	42	0.034	0.21	1,224
Sculpin	148	0.121	0.74	1,224

Table 3.4.2 Total number, density, and relative abundance of each species caught during relative abundance surveys on Wolf Fork.

SPECIES	# CAPTURED	DENSITY (#/100m²)	Rla	AREA SAMPLED (m²)
Bull Trout	11	0.007	0.05	1,628
Steelhead Trout	182	0.112	0.76	1,628
Sculpin	47	0.030	0.20	1,628

Table 3.4.3. Total number, density, and relative abundance of each species caught during relative abundance surveys on the Tucannon River.

SPECIES	# CAPTURED	DENSITY (#/100m²)	Rla	AREA SAMPLED (m²)
Bull Trout	20	0.020	0.12	968
Steelhead Trout	86	0.087	0.50	968
Sculpin	67	0.068	0.21	866

Table 3.4.4. Total number, density, and relative abundance of each species caught during relative abundance surveys on Asotin Creek.

SPECIES	# CAPTURED	DENSITY (#/100m²)	Rla	AREA SAMPLED (m²)
Bull Trout	0	0	0	321
Steelhead Trout	63	0.196	0.24	321
Sculpin	204	0.636	0.76	321

3.5 HABITAT UTILIZATION AND PREFERENCE ANALYSIS

After compiling the habitat inventory segment data for each stream, and site habitat characteristics, habitat utilization and preference histograms were constructed for each species and stream surveyed. Habitat utilization histograms were constructed for bull trout and steelhead trout utilizing gravel substrate, cobble substrate, boulder substrate, sites with overhead cover, woody debris, boulders, undercut banks, and turbulence. All habitat utilization histograms are presented in Appendix C.

Results of the site habitat characteristic data showed that habitat use varied between streams and between species and that few strong correlations between use and specific site habitat characteriscits existed for most of the parameters measured. The correlations that existed between use and availability were; 1)young of the year bull trout showed density increases (use), with Increases of boulder and overhead cover in survey sites in all 3 streams containing bull trout, 2)Juvenile bull trout showed density increases (use), in use of cobble and overhead cover as these instream cover types increased in survey sites in ail 3 streams, 3) bull trout showed density decreases (use), with increases in turbulence in survey sites in all 3 streams, and 4) young of the year steelhead trout showed density increases (use); with increases of gravel and woody debris in survey sites in all 3 streams. Steelhead showed density decreases (use), with increases in turbulence in survey sites in all 3 streams.

Habitat availability and fish utilization histograms were constructed for each species of fish in each of the study streams for habitat that could be quantified (Figure 3.5.1 through 3.5.4). There were' consistent relationships between habitat use and age class for each stream. Young of the year bull trout consistantly utilized riffle or cascade habitat the highest in each of the study streams (Fig. 3.5.1.), while juvenile bull trout consistently utilized plunge pool or scour pool habitat the highest in each of the study streams (Fig. 3.5.2.). Young of the year steelhead trout consistandy utilized plunge pool or scour pool habitat the highest in each of the study streams (Fig. 3.5.3.), while juvenile steelhead trout utilized either plunge pool, scour pool, or run habitat (Fig. 3.5.4.).

After transformation of habitat utilization to habitat preference, certain habitat preference relationships existed. Young of the year bull trout showed higher preference for pools than the other habitat types, but preference values for run, riffle, and cascade habitat still existed (Fig. 3.5.1.). Juvenile bull trout, however, showed strong preference for pool habitat and the preference values for the other habitat types became almost zero (Fig. 3.52.). Young of the year and juvenile steelhead trout showed strong preference for pool habitat but values for the other habitat types remained above zero (Figures 3.5.3. and 3.5.4.).

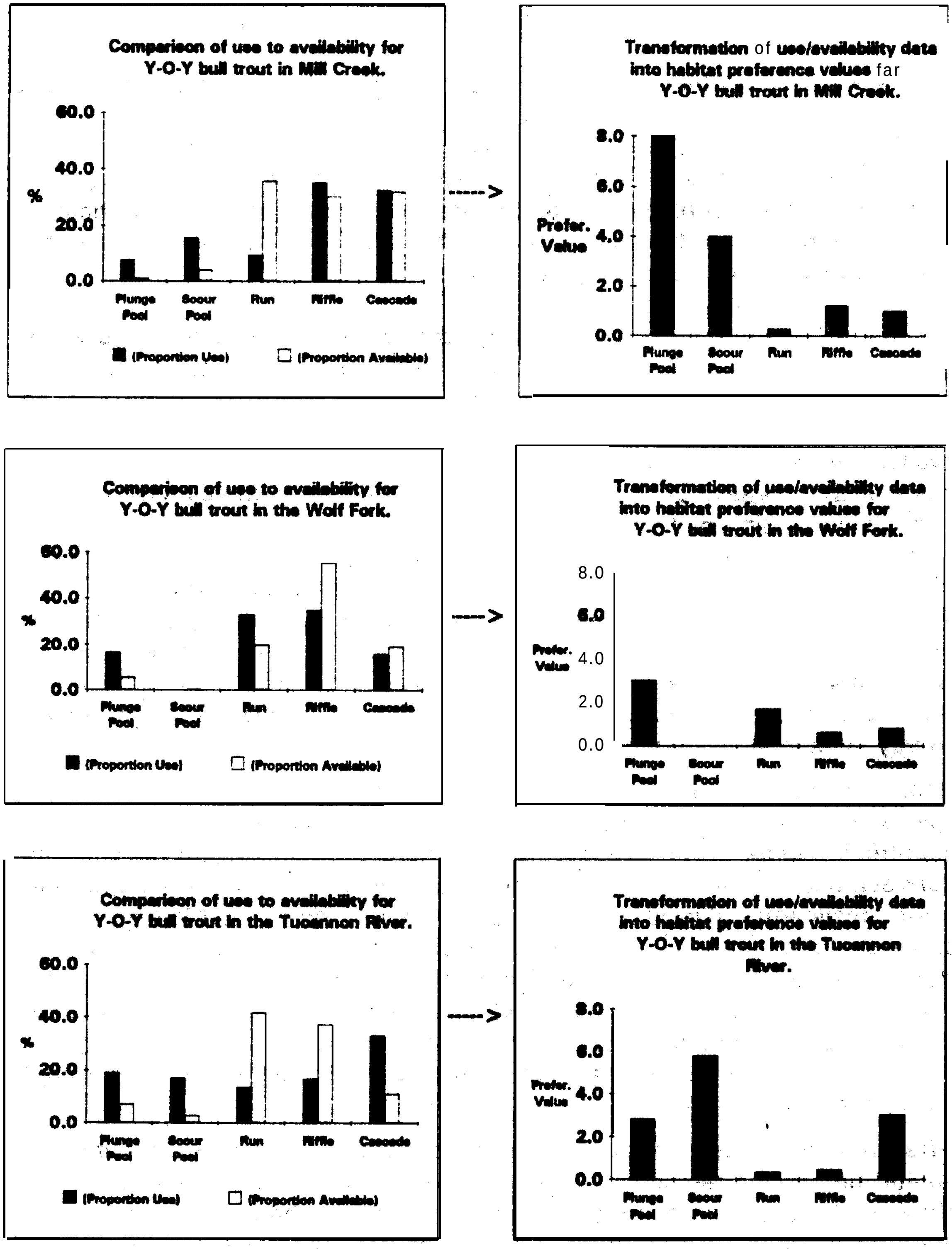

Figure 3.5.1. **Comparison** of **percent** habitat **use to** percent habitat **availability** and **habitat preference values** for **Young-of-the-year** bull trout in **each** of **the study streams,** 1991.

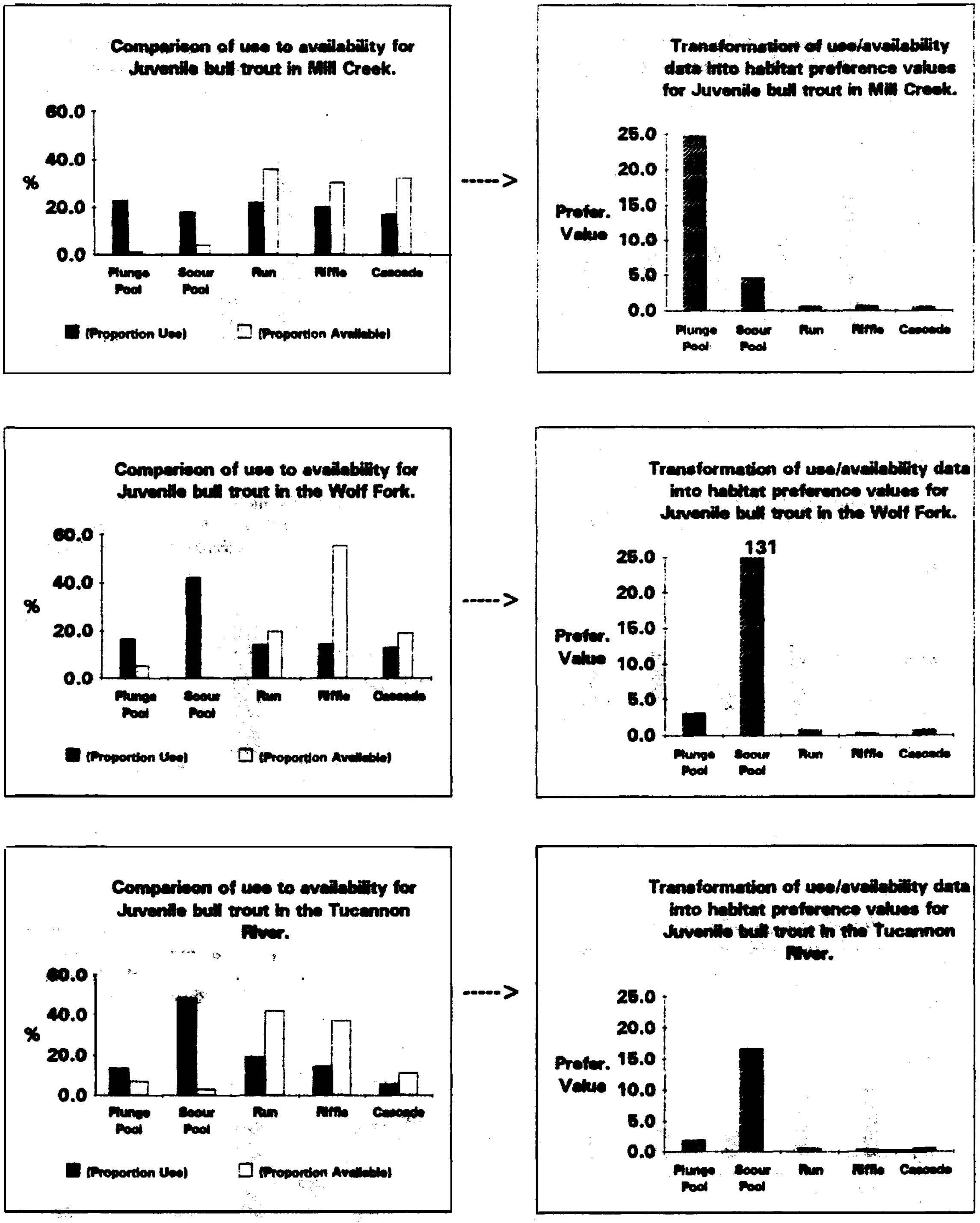

Figure **3.6.2. Comparison** of **percent habitat use to percent** habitat **availability and habitat preference values** for Juvenile **bull trout in each of the study streams,** 1991.

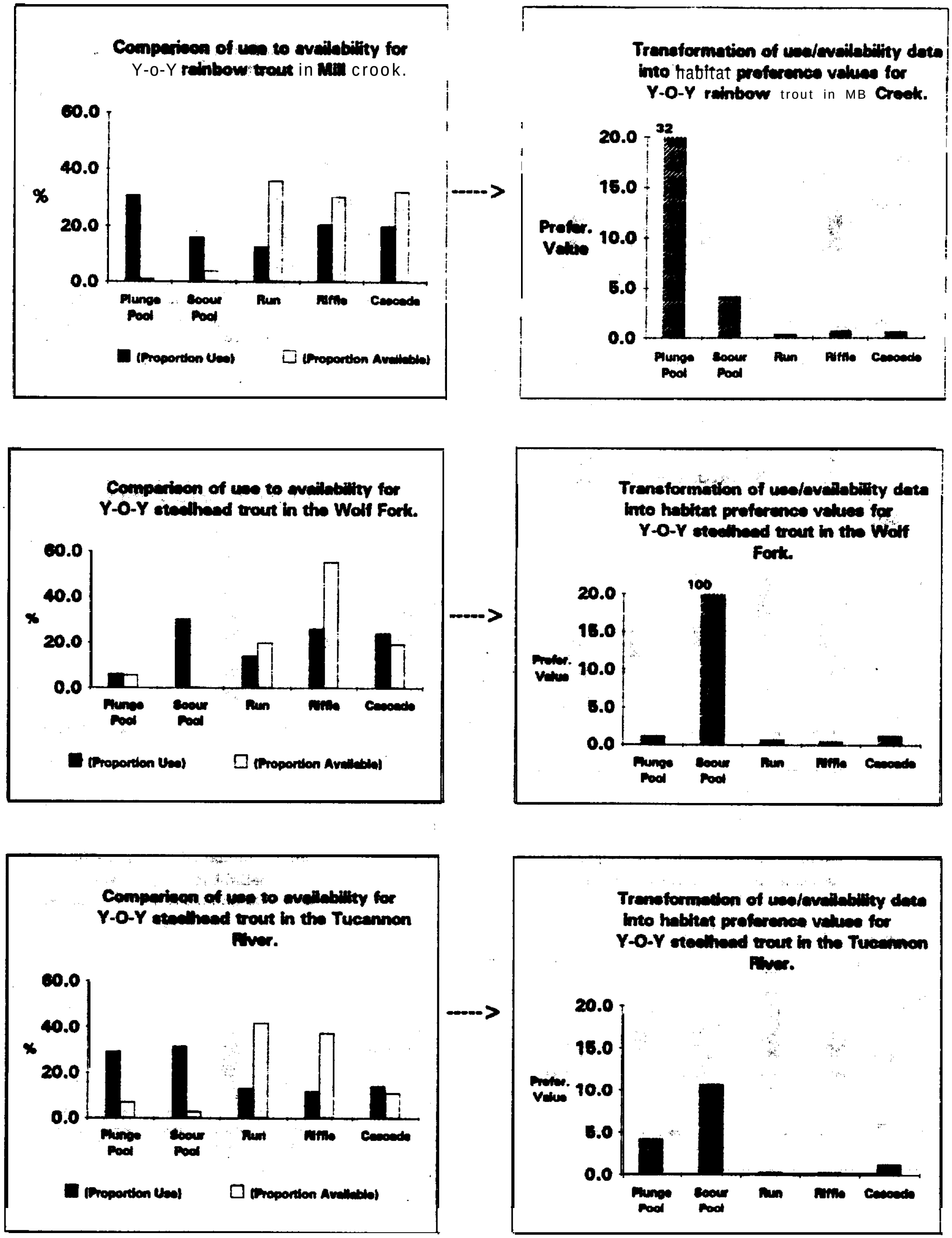

Figure 3.5.3. Comparison of percent habitat use to percent habitat availability and habitat preference values for Young-of-the-Year steelhead trout In each of the study streams, 1991.

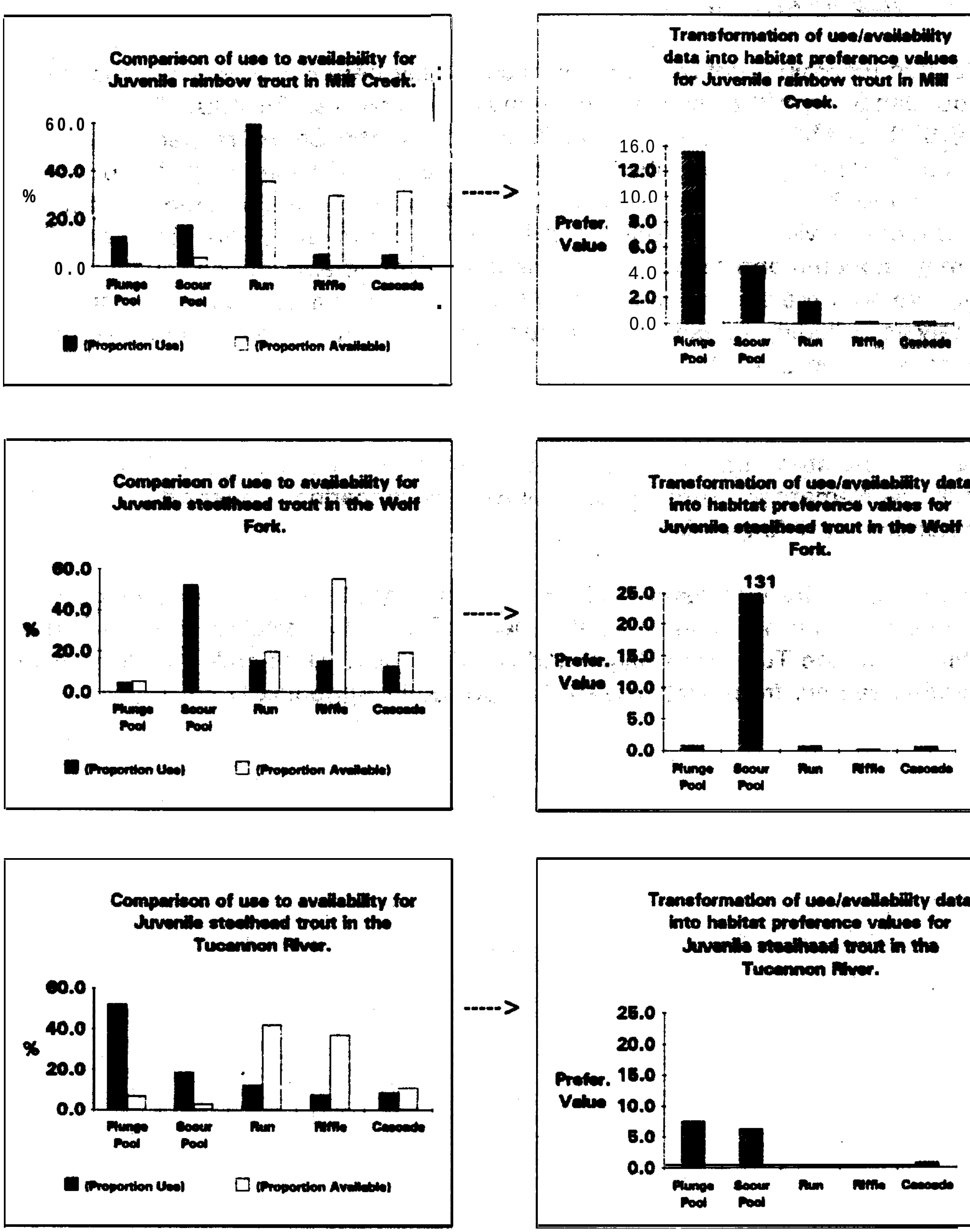

Figure 3.5.4. Comparison of percent habitat use to percent habitat availability and habitat preference values for Juvenile steelhead trout in each of the study streams, 1991.

3.6 FOOD A *VAILABILITY*

Benthic macroinvertebrate density was similiar b&v&n streams. The total abundance (#/m2) of benthic macroinvertebrates was 26,480, 20,383, and 16,678 for Mill Creek, Tucannon River, and Asotin Creek, respectively. The Order Diptera was the highest in abundance in 'Mill Creek (52%) and the Tucannon River (35%). The Order Ephemeroptera was the second most, abundant in Mill Creek (20%) and the Tucannon River (14%). In Asotin Creek, Ephemeroptera was the highest in terms of abundance-(44%) and Diptera was the second most abundant (33%) (For a complete tabular analysis including density and percentages of each organism identified in each river see table 3.6.1.).

Figure 3.6.1. shows a comparison of benthic macroinvertebrate densities in each of the study streams that were inventorled. The category, "rest" includes Nematoda, Turbellaria, Mollusca, Hydracarina, Copepoda, Ostacoda, and- Amphibia.

Food availability was estimated for the Wolf Fork by taking the average, of the numerical proportion of 'each Order or Class of invertebrates identified in Mill Creek, the Tucannon River, and Asotin Creek. Data collected from each benthic sample from each stream is reported in Appendix D.

TABLE 3.6.7.

Comparison of summer benthic macroinvertebrate densities and the percent of the total *for* each invertebrate identified (proportions less than 0.001 are shown as <0.01). Data is from Hess samples, July, 1991.

	MILL CREEK DENSITY (#/ SQ. M)	% OF TOTAL	TUCANNON RIVER DENSITY (#/ SQ. M)	% OF TOTAL	ASOTIN CREEK DENSITY (#/ SQ. M)	% OF TOTAL
DIPTERA						
Blephariceridae					231	1.4%
Chronomidae	12880	49.5%	3413.3	17.3%	2853.0	17.2%
Chironomid pupa	187	0.7%	3413.3	17.3%	62.0	0.4%
Ceratopogonidae	53	0.2%	44.4	0.2%	116.0	0.7%
Empididae	27	0.1%				
Pelecorhychidae	107	0.4%			80.0	0.5%
Empidae	27	0.1%				
Simulidae	613.0	2.4%	142.0	0.7%	1858.0	11.2%
Simulidae pupa			17.8	0.1%	27.0	0.2%
Tabanidae						
Tipulidae			17.8	0.1%	213.0	1.3%
TOTAL DIPTERA		53.4%		35.6%		32.8%
TRICHOPTERA						
Brachycentridae	80	0.3%	133.3	0.7%	187.0	1.1%
Glossosomatidae			97.8	0.5%	27.0	0.2%
Hydropsychidae						
Leptoceridae	213	0.8%		<0.01	267.0	1.6%
Limnephilidae						
Philopotamidae			0.6	<0.01		
Rhyacophilidae	213	0.8%			36.0	0.2%
Trichop. pupa	27	0.1%	222.2	1.1%	27.0	0.2%
TOTAL TRICHOPTERA		2.1%		2.3%		3.3%
COLEOPTERA						
Hydrophilidae			8.1	<0.01		
Elmidae larva	320	1.2%	702.2	3.6%	1289.0	7.8%
Elmidae adult					204.0	1.2%
TOTAL COLEOPTERA		1.2%		3.6%		9.0%
PLECOPTERA						
Chloroperlidae	2347	9.0%	382.2	1.9%	71.0	0.4%
Nemouridae	53	0.2%	1520.0	7.7%	667.0	4.0%
Perlidae	133	0.5%	160.0	0.8%	364.0	2.2%
Perlodidae						
Pteronarcyidae					26.7	0.2%
TOTAL PLECOPTERA		9.7%		10.4%		6.8%
EPHEMEROPTERA						
Baetidae	3627	14.0%	1226.7	6.2%	6044.0	36.5%
Ephemerellidae	693	2.7%	577.8	2.9%	329.0	2.0%
Heptageniidae	853	3.3%	1120.0	5.7%	1200.0	7.2%
Leptophlebiidae			26.7	0.1%	53.0	0.3%
TOTAL EPHEMEROPTERA		19.[illegible]		14.9%		46.0%
OLIGOCHAETA	800	3.1%	2951.5	14.3%	71.0	0.4%
TURBELLARIA			[illegible]	18.0%		
MOLLUSCA	1573	6.1%			36.0	0.2%
HYDRACARINA			26.7	0.1%	187.0	1.1%
COPEPODA	27	0.1%			36.0	0.2%
OSTRACODA	1147	4.4%				
AMPHIBIAN			8.4	< .01		

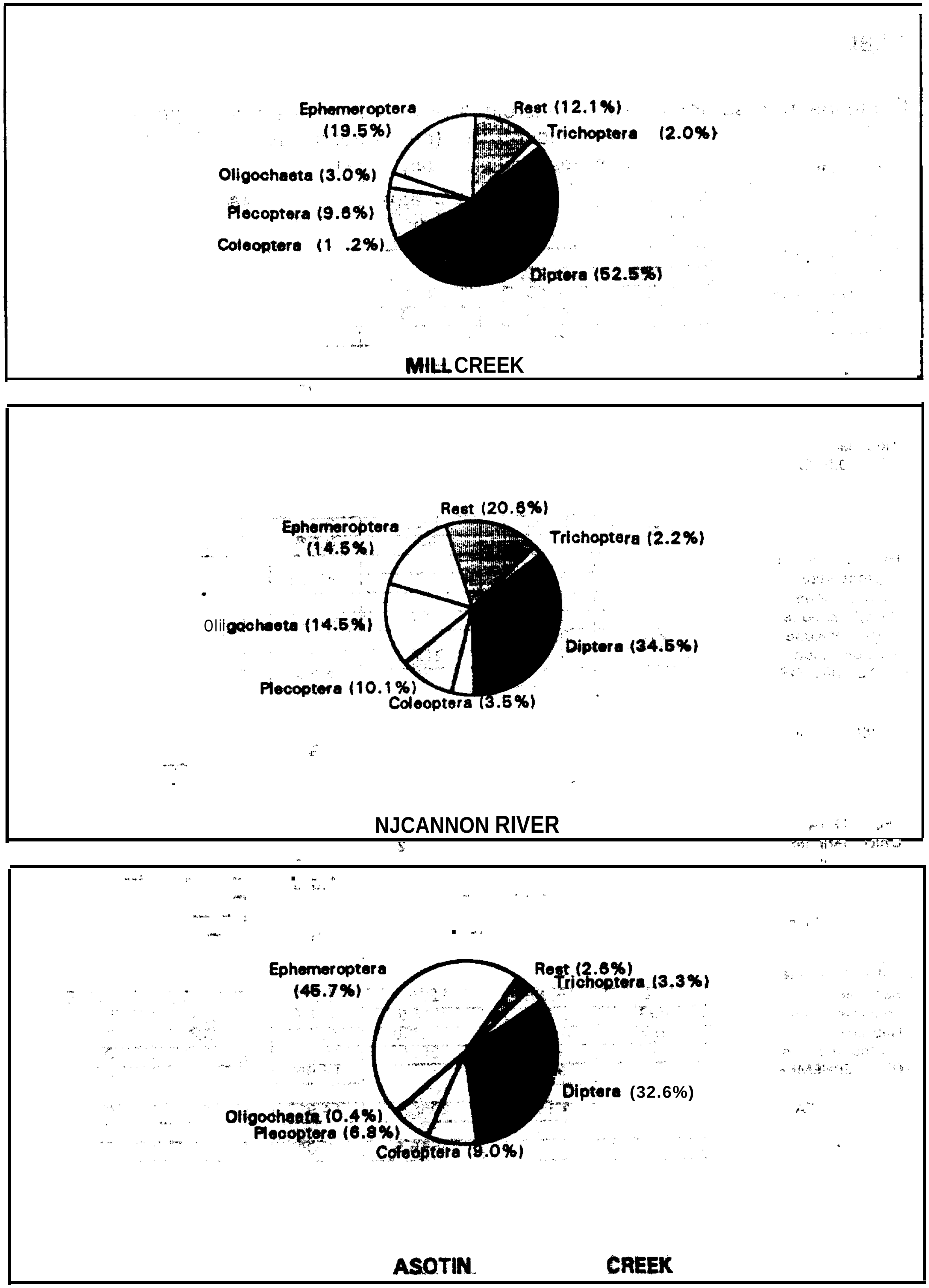

Figure. 3.6.1. **Benthic macroinvertebrate** density comparisons **between** study streams, 1991.

3.7 FEEDING HABITS

Juvenile bull trout and steelhead trout/rainbow trout were collected from Mill Creek, the Wolf Fork, and the Tucannon River in the fourth week of July and in the fifth week of August, 1 991 (See table 3.7.1. for collection dates and the number of fish collected).

One adult bull trout (625 mm FL) was collected from Mill Creek on July 2, two bull trout (325 mm and 470 mm FL) from the Wolf Fork on July 23, and one adult bull trout (373 mm FL) from the Tucannon River on August 27, 1991. The 328 mm bull trout collected from the Wolf Fork was the only one of thase four fish that had any food items present in it's stomach. No fish were collected from Asotin Creek due to the depressed population in this rivet.

Bull trout and steelhead/rainbow trout were also collected in 1990, which will be included in the diet analysis portion of this study.

In 1990, eight bull trout (range, 275 mm to 560 mmFL), seven juvenile rainbow trout, and six adult rainbow trout were collected from Mill Creek-in the third week of August. All eight bull trout stomachs were empty. Two adult bull trout (273 and 254 mm FL), one juvenite bull'trout, and four juvenile steelhead trout were collected on August 2, 1990, from the Tucannon River. Seven juvenile steelhead trout and six adult rainbow trout were collected from the Tucannon River on October 2, 1990.

Table 3.7.1. Juvenile fish stomachs collected from each stream, 1991.

STREAM & DATE	BULL TROUT	RAINBOW TROUT
Mill Cr. July 25	10	10
Mill Cr., August 29	10	12'
wolf Fork July 23	8	11
Wolf Fork August 28	11	8
Tucannon R. July 24	10	9
Tucannon R. August 28	11	10

Information about each fish collected for stomach analysis is reported in Appendix E (date of capture, fork length, frequency of occurrence, number, weight, and relative. importance of each food item).

3.7.1. INDEX OF RELATIVE IMPORTANCE

The principal foods of bull trout and steelhead trout/rainbow trout were similiar as indicated by the Index of Relative Importance. While the principal foods of bull trout and spring chinook salmon were dissimiliar as indicated by the Index of Relative Importance. The percent by number, percent by weight, and frequency of occurrence data used to calculate the index of relative importance (IRI) is reported in tables 3.7.1 .1 . through 3.7.1.5. for Mill Creek, Wolf Fork, and the Tucannon River, respectively.

Mill Creek. In July, 1891, the most important food item (IRI) found in juvenile bull trout in Mill Creek was Plecoptera (48.2), followed by Ephemeroptera (22.1). In August, 1881, the most important food item (IRI) of juvenile bull trout in Mill Creek was Cotddae (45.4), followed by Ephemeroptera (42.2). (see table 3.7.1.1). In July, 1981, the most important food item (IRI)of juvenile rainbow trout in Mill Creek was Gastropoda (31.1), follwed by Ephemeroptera (18.1). In August, 1891, the most important food item (IRI) of juvenile rainbow trout in Mill Creek was terrestrial invertebrates (39.9), followed by Ephemeroptera (36.8) (See table 3.7.1 .1.).

In August, 1990, the most important food item (IRI) of juvenile rainbow trout in Mill Creek was terrestrial invertebrates (41.81, followed by Diptera (8.1). In August, 1 991 , the mostimportant. food item (IRI) of adult rainbow trout in Mill Creek was Gastropoda (28.4), followed by terrestrial invertebrates (21 .O) (See table 3.7.1.2.).

Wolf For&. in July, 1981, the most important food item (IRI) found in juvenile bull trout in the' Wolf Fork was Plecoptera (44.8), follwed by Trichoptera (22.9). In August, 1991, the most important food item (IRI) of juvenile bull trout in the Wolf Fork was Ephemeroptera (26.51, followed by Cottidae (23.6) (See table 3.7.1.3.). In July, 1891, the most important food item (IRI) of juvenile steelhead trout in the Wolf Fork was Plecoptera (28.91, followed by Ephemoptera (22.3). In August, 1981, the most important food item (IRI) of juvenile steelhead trout in the Wolf Fork was terrestrial invertebrates (34.0); followed by Ephemeroptera (33.8) (See table 3.7.1.3.).

Tucannon River. In July, 1981, the most important food item (IRI) found in juvenile bull trout in the Tucannon River 'was Oligochaeta (38.21, followed by Plecoptera (14.0). In August, 1891, the most important food item (IRI) of juvenile bull trout in the Tucannon River was Oligochaeta (15.5), followed by Ephemeroptera (12.3) (See table 3.7.1.4.). In July, 1891, the most important food item (IRI) of juvenile steelhead trout was Plecoptera (29.4), followed by Ephemeroptera (24.6). In August, 1881, the most important food item (IRI) of juvenile steelhead trout in the Tucannon River was Plecoptera (25.9), followed by Ephemeroptera (22.4) (See table 3.7.1.4.).

The mean index of relative importance for each food item of bull trout in July and August., 1991 showed that Oligochaeta (26.8) was followed by Diptera (12.0) in order of importance. These values were compared to those reported in Bugert (1990) for spring chinook salmon. The most important food item, of spring chinook salmon in the Tucannon River in the summer of 1989 was Coieoptera (38.9), followed by Ephemeroptera (29.2) (See table 3.7.1.4.).

The, most, important food item (IRI) of juvenile rainbow trout in Mill Creek in August, 1990, was Coleoptera (45.41, followed by terrestrial invertebrates (36.0). The most important "food item (IRI) of adult rainbow trout in Mill Creek in August, 1990, was Trichoptera (56.0), followed by Cottidae (27.2) (See table 3.7.1 .5.).

TABLE 3.7.1.1.

Diet comparisons and Index of Relative Importance (IRI) for juvenile bull trout and rainbow trout in Mill Creek, July 27, 1991.

	JUVENILE BULL TROUT (n = 10)				JUVENILE RAINBOW TROUT (n = 10)			
ORGANISM	% BY NUMBER	% BY WEIGHT	FRED. OCCUR.	IRI	% BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI
DIPTERA	13.33	0.24	0.8	0.88	3.84	0.03	0.2	2.
TRICHOPTERA	4.44	0.64	0.2	0.32	12.13	1.43	0.3	3.37
COLEOPTERA	1.11	1	0.1	0.14	1.28	0.02	0.2	0.74
PLECOPTERA	16.67	30.19	0.3	6.01	3.21	3.36	0.5	6.32
EPHEMEROPTERA	43.33	0.66	0.3	2.71	36.16	8.41	0.3	21.78
OLIGOCHAETA	5.55	0.26	0.2	0.37				
NEMATODA					37.82	0.69	0.8	19.28
TURBELLERIA	2.22	0.01	0.1	0.14				
COTTIDAE	1.11	16.06	0.1	1.				
TERRESTRIALS	5.66	0.08	0.3	0.37	10.9	4.16	0.7	7.73
LEPIDOPTERA	2.22	2.03	0.1	6.27	1.28	7.33	0.1	1.33
GASTROPODA					0.64	75.39	0.1	37.34
UNIDENTIFIED PARTS	3.33.	0.03	0.2	0.22	0.64	0.17	0.1	0.45

Diet comparisons and Index of Relative Importance (IRI) for juvenile bull trout and rainbow trout in Mill Creek, August 28, 1991 .

	JUVENILE BULL TROUT (n = 10)				JUVENILE RAINBOW TROUT (n = 10)			
ORGANISM	% BY NUMBER	% BY WEIGHT	FRED. OCCUR.	IRI	% BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI
DIPTERA	3.46	0.44	0.4	2.62	4.03	1.2	0.42	3.82
TRICHOPTERA	0.69	0.3	0.1	0.43	2.37	5.49	0.5	3.17
COLEOPTERA					1.33	1.14	0.26	1.46
PLECOPTERA	4.83	4.81	0.6	4.79	4.08	8.53	0.6	6.21
EPHEMEROPTERA	91.37	4.28	0.8	42.53	ea.79	6	0.83	a 6 . M
OLIGOCHAETA								
NEMATODA					0.6	0.02	0.17	0.26
TURBELLERIA								
COTTIDAE	3.45	88.39	0.5	46.61				
TERRESTRIAL8	4.83	0.77	0.4	2.78	16.17	65.1	0.83	39.39
LEPIDOPTERA	1.38	1.01	0.2	1.19	2.62	11.28	0.33	6.8
GASTROPODA								
UNIDENTIFIED PARTS					0.5	1.22	0.08	0.16

TABLE 3.7.1.2.

Diet comparisons and Index of Relative Importance (IRI) for juvenile and adult rainbow trout in Mill Creek, August, 1990.

ORGANISM	JUVENILE STEELHEAD TROUT (n = 7) % BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI	ADULT RAINBOW TROUT (n = 6) % BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI
DIPTERA	13.16	7.39	0.71	8.13	2.94	0.37	0.29	1.77
TRICHOPTERA	4.52	5.37	0.71	4.16	1.48	1.48	0.29	1.6
COLEOPTERA	0.41	1.13	0.14	0.62				
PLECOPTERA	2.47	7.76	0.71	4.07	2.94	11.73	0.29	7.36
EPHEMEROPTERA	13.67	6.63	1	7.63	2.96	0.22	0.43	1.77
OLIGOCHAETA	0.41	0.24	0.14	0.23				
TURBELLERIA								
COTTIDAE					0.74	14.03	0.14	7.33
TERRESTRIALS	49.38	62.18	1	41.84	28.68	13.05	0.86	20.95
LEPIDOPTERA	0.41	3.62	0.13	1.66				
GASTROPODA					0.74	56.93	0.14	28.43
UNIDENTIFIED PARTS	1.23	3.48	0.38	0.46	0.74	0.06	0.14	0.46

TABLE 3.7.1.3.

Diet comparisons and Index of Relative Importance (IRI) for juvenile bull trout and steelhead trout in the Wolf Fork River, July 23, 1991.

	JUVENILE BULL TROUT (n = 8)				JUVENILE STEELHEAD TROUT (n = 11)			
ORGANISM	% BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI	% BY NUMBER	% BY WEIGHT	FRED. OCCUR.	IRI
DIPTERA	9.37	0.16	0.38	4.84	12.18	10.93	0.54	12.34
TRICHOPTERA	25.67	19.72	0.63	22.91	23.24	24.27	1	25.2
COLEOPTERA				0.	0.7	0.19	0.09	0.51
PLECOPTERA	18.45	72.57	0.53	44.81	7.04	48.25	0.27	28.85
EPHEMEROPTERA	34.38	2.5	0.88	18.49	32.39	9.57	0.91	22.27
OLIGOCHAETA	1.41	0.24	'0.13	0.87				
TURBELLERIA	1.55	0.07	0.18	0.85				
COTTIDAE								
TERRESTRIALS	3.13	1.83	0.26	2.4	8.46	1.99	0.35	5.61
LEPIDOPTERA	1.55	0.02	0.13	0.84	1.41	1.48	0.09	1.56
BIVALVE					0.7	0.02	0.09	0.42
UNIDENTIFIED PARTS	4.59	3.31	0.26	3.98	4.23	1.55	0.36	3.25

Diet comparisons and Index of Relative Importance (IRI) for juvenile bull trout and steelhead trout in the Wolf Fork River, August 28, 1991.

	JUVENILE BULL TROUT In = 11)				JUVENILE BTEELHEAD TROUT (n = 9)			
ORGANISM	% BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI	% BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI
DIPTERA	23.56	3.75	0.82	13.85	5.3s	1.75	0.65	4.39
TRICHOPTERA	7.87	2.77	0.54	1.64	8.52	12.91	0.67	11.14
COLEOPTERA	2.42	9.42	0.27	6.95	0.43	0.43	0.11	0.49
PLECOPTERA	7.85	23.39	0.73	16.72	4.25	25.98	0.57	15.08
EPHEMEROPTERA	43.53	9.45	0.82	26.48	48.54	17.84	0.89	33.91
OLIGOCHAETA	0.51	0.89	0.09	0.78				
TURBELLERIA								
COTTIDAE	0.51	47.24	0.09	23.66				
TERRESTRIALS	11.52	2.71	0.55	7.15	27.23	39.42	0.75	33.99
LEPIDOPTERA								
HYDRACARINA	0.51	0.05	0.09	0.37				
UNIDENTIFIED PARTS	0.51	0.28	0.09	0.4%				

TABLE 3.7.1.4.

Diet comparisons and Index-of Relative Importance (IRI) for juvenile bull trout and steelhead trout in the Tucannon River, July 24," 1991.

ORGANISM	JUVENILE BULL TROUT (n = 10) % BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI	JUVENILE STEELHEAD TROUT (n = 9) % BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI
DIPTERA	10.01	15.39	0.3	13.41	16.89	2.97	0.78	10.17
TRICHOPTERA	1.76	0.87	0.2	1.89	14.29	9.97	0.89	12.39
COLEOPTERA	2.54	0.05	0.2	1.42	1.95	2.23	0.33	2.22
PLECOPTERA	7.08	21.1	0.4	14.04	6.84	53.49	0.55	29.85
EPHEMEROPTERA	j8.58	3.12	0.0	11.1	40.91	8.04	0.89	24.55
OUGOCHAETA	30.97	45.6	0.2	35.15				
TURBELLERIA					1.3	0.55	0.1'1	1.02
COTTIDAE	0.88	5.22	0.1	3.54				
TERRESTRIALS	15.81	2.81	0.6	9.88	5.84	10.85	0.33	8.39
LEPIDOPTERA	7.95,	1.48	0.2	4.74	5.4s	6.04	0.44	5.9
BIVALVE								
UNIDENTIFIED PARTS	2.56	1.79	0.3	2.33	4.55	5.54	0.55	5.79

Diet comparisons and Index of Relative Importance (IRI) for both juvenile bull trout and steelhead trout in the Tucannon River, August 27, 1991.

ORGANISM	JUVENILE BULL TROUT (n = 10) % BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI	JUVENILE STEELHEAD TROUT (n = 9) % BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI
DIPTERA	21.43	1.24	0.4	10.63	8.1	2.1	0.6	5.39
TRICHOPTERA	14.29	2.55	0.3	7.9	17.11	5.93	0.5	12.4
COLEOPTERA	1.79	0.73	0.1	1.21	0.9	b.47	0.1	0.74
PLECOPTERA	8.93	2.81	0.6	6.54	9.01	41.74	0.7	25.89
EPHEMEROPTERA	21.43	4.59	0.5	12.27	37.83	5.78	0.8	22.35
OLIGOCHAETA	3.57	29.75	0.2	16.46				
TURBELLERIA								
COTTIDAE	1.79	18.04	0.4	9.32	0.9	17.08	0.1	9.1
TERRESTRIALS	12.S.	9.03	0.5	10.15	15.32	14.65	0.5	15.34
LEPIDOPTERA	3.57	14.01'	0.1	8.15	4.5	11.44	0.3	8.17
OSTRACODA	3.67	0.31	0.1	1.83				
AMPHIBIAN	1.79	12.94	0.1	5.83				
UNIDENTIFIED PARTS	20	2.92	0.1	10.51				

TABLE 3.7.1.4. (cont.)

Diet comparisons between bull trout (mean IRI for July and August, 1991; taken from table 3.8.1.4., above) and spring chinook salmon collected in 1989 from the Tucannon River.

ORGANISM	SPRING CHINOOK SALMON (n = 36) % BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI	BULL TROUT IRI
DIPTERA	9.7	2.5	19.4	8.01	12.02
TRICHOPTERA	4.2	5.9	6.5	4.22	4.65
COLEOPTERA	47.6	15.5	90.1	38.94	1.32
PLECOPTERA	9.9	4.7	33.3	12.11	9.84
EPHEMEROPTERA	24.9	16.5	76	29.15	11.69
OLIGOCHAETA	0.7	3.7	2.8	1.82	26.8
TURBELLERIA					
COTTIDAE					6.43
TERRESTRIALS					10.02
LEPIDOPTERA					6.45
UNIDENTIFIED PARTS	10.8	6.3	5.6	5.74	6.47

TABLE 3.7.1.5.

Diet comparisons between juvenile steelhead trout and adult rainbow trout collected in August, 1989 from the Tucannon River.

ORGANISM	JUVENILE STEELHEAD TROUT (n = 7) % BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI	ADULT RAINBOW TROUT (n = 6) % BY NUMBER	% BY WEIGHT	FREQ. OCCUR.	IRI
DIPTERA					0.65	0.02	0.17	0.55
TRICHOPTERA	5.98	5.96	0.57	3.98	12.22	51.88	0.83	56.03
COLEOPTERA	47.6	15.6	90.1	45.41	8.34	0.08	0.17	2.68
PLECOPTERA	9.9	4.7	33.3	14.11				
EPHEMEROPTERA	1.09	2.55	0.14	1.14				
OLIGOCHAETA				0.				
TURBELLERIA					5.57	10.5	0.85	13.48
COTTIDAE					0.55	36.7	0.17	27.24
TERRESTRIALS	36.33	82.9	0.57	36.01				
LEPIDOPTERA								
UNIDENTIFIED PARTS	0.64	0.62	0.14	0.38				

3.7.2 DIET OVERLAP

Since diet overlap calculatioins are based on the numerical presence or absence of a particular organism, an&hat each organism can be eaten by either species, we calculated diet overlap for the lowest taxonomic level possible. identification to the lowest taxonomic level was influenced by the amount of digestion that had occurred prior to removal from the stomach. Table 3.7.2.1. reports the diet overlap values between species for each study stream and month for each taxa of invertebrate reoprted. The diet overlap computations are reported in Appendix E.

Diet overlap between juvenile bull trout and rainbow trout in Mill Creek was 0.81 for the month of July (Appendix E, table 19.), and 0.43 for the month of August, 1991 (Appendix E table 20). From this data we infer little to 'no competition,

Diet overlap between juvenile bull trout and juvenile steelhead trout in the Wolf Fork River was, 0.84 for the month of July (Appendix E table 21) and 0.84 fur the month of August, 1991 (Appendix E table 22). This data implies that there may be competition for available food in this stream.

Diet overlap between juvenile bull trout and juvenile steelhead trout in the Tucannon River was 0.39 for the month of July (Appendix E table 23), and 0.61 for the month of August, 1991 (Appendix E table 24). From this data we infer little to no competition.

A comparison of the 1989 spring chinook salmon diet analysis on the Tucannon River (Bugert 1990) to the 1991 bull trout diet analysis on the Tucannon River showed a diet overlap value of *0.08* (Appendix E table 24). From this limited amount of data, we infer no competition.

3.7.3. ELECTIVITY INDEX

Electivity indices, which indicate if a fish is selectively preying on a particular taxa of invertebrates, were calculated for juvenile bull trout and steelhead trout in Mill Creek, Wolf Fork, and the Tucannon River.

Benthic macroinvertebrate electivity values for juvenile bull trout and steelhead trout in Mill Creek are listed in table 3.7.3.1. Electivity for benthic macroinvertebrates by juvenile bull trout was highest for Ephemeroptera (0.234) followed by Plecoptera (0.069). Electivity values for rainbow trout in Mill Creek were highest for Ephemeroptera (0.153) followed by Trichoptera (0.031).

Benthic macroinvertebrate electivity values for juvenile bull trout and steelhead trout in the Wolf Fork are listed in table 3.7.3.2. Electivity for benth,ic macroinvertebrates by juvenile bull trout was highest for Trichoptera (0.241), followed by. Plecoptera (0.084). Electivity values for steelhead trout in the Wolf Fork were highest for Trichoptera (0.2331, followed by Molusca (0.052).

Table 3.7.2.1. Diet overlap values between species for each study stream and month.

SPECIES	RIVER	MONTH	OVERLAP VALUE
Bull trout/Rainbow	Mill Creek	July, 1991	0.51
Bull Trout/Rainbow	Mill Creek	August, 1991	0.43
Bull trout/Steelhead	Wolf Fork	July, 1991	0.82
Bull trout/Steelhead	Wolf Fork	August, 1991	0.84
Bull trout/Steelhead	Tucannon R.	July, 1991	0.39
Bull trout/Steelhead	Tucannon R.	August, 1991	0.61
Bull trout/Chinook	Tucannon R.	1991 - 1989	0.08

Benthic macroinvertebrate electivity values for juvenile bull trout and steelhead trout in the Tucannon River are listed in table 3.7.3.3. Electivity for benthic macroinvertebrates by juvenile bull trout was highest for Ephemeroptera (0.016), followed by Oligochaeta (0.014). Electivity values for steelhead trout in the Tucannon River were highest for Ephemeroptera (0.240), followed by Trichoptera (0.1171.

Benthic macroinvertebrate electivity values for spring chinook salmon and steelhead trout in the Tucannon River were determined by Bugert (1990) and are reported in table 3.7.3.4. Electivity was highest by spring chinook salmon for Chironomidae (0.671, followed by Ephemeroptera (0.67). Electivity values for steelhead trout in the Tucannon River, 1989, were highest for Baetidae (0.491, followed by Nematoda (0.06).

TABLE 3.7.3.1.

Mill Creek electivitiy indices for rainbow trout and bull trout. Benthic macroinvertebrate densities were quantified in the gut and the environment and converted into percentages, July, 1991.

ORGANISM	ENVIRONMENT	RAINBOW TROUT	ELECTIVITY INDEX	BULL TROUT	ELECTIVITY INDEX
DIPTERA					
Chironomidw	0.495	0.0266	-0.47	0.0666	-0.44
Chironomid pupa	0.007			0.111	0.104
Ceratopogonidae	0.002				
Empididae	0.001				
Pelecorhychidae	0.004	0.0218	0.018	0.0444	0.04
Empidae	0.001				
Simulidae	0.024			0.0111	-0.012
TOTAL DIPTERA	0.534	0.0474	-0.487	0.2221	-0.312
TRICHOPTERA					
Brachycentridae	0.003				
Glossosomatidae		0.0064		0.0333	
Hydropsychidae		0.0128			
Leptoceridae	0.008				
Limnephilidae		0.0321			
Rhyacophilidae	0.008			0.0111	0.003
Trichop. pupa	0.001				
TOTAL TRICHOPTERA	0.021	0.0513	0.031	0.0444	0.024
COLEOPTERA					
Carabidae				0.0111	
Gyrinidae		0.0064			
Elmidae larva	0.012				
Elmidae adult		0.0064			
TOTAL COLEOPTERA	0.012	0.0128	0.	0.0111	-0.001
PLECOPTERA					
Chloroperlidae	0.09			0.0111	-0.079
Nemouridae	0.002				
Perlidae	0.00S	0.0321	0.027	0.1556	0.15
TOTAL PLECOPTERA	0.097	0.0321	-0.065	0.1667	0.069
EPHEMEROPTERA					
Baetidae	0.14	0.2372	0.098	0.3333	0.194
Ephemerellidae	0.027	0.0266	-0.001	0.0333	0.007
Heptageniidae	0.033	0.0667	0.066	0.0667	0.034
TOTAL EPHEMEROPTERA	0.168	0.3618	0.153	0.4333	0.234
OUGOCHAETA	0.031				
TURBELLARIA				0.0222	
MOLLUSCA	0.061				
COPEPOOA	0.001				
OSTRACODA	0.044				
LEPIDOPTERA		0.0128		0.0222	

TABLE 3.7.3.2.

Wolf Fork electivity indices for steelhead trout and bull trout. Benthic macroinvertebrate densities were quantified in the gut and converted' into percentage. Invertebrate density values are the mean value of Mill Creek, Tucannon, River, and Asotin Creek densities, (see tables 3.8.3.1, 3.8.3.3, and 3.8.3.4.).

ORGANISM	ENVIRONMENT	STEELHEAD TROUT	ELECTIVITY INDEX	6UU TROUT	ELECTIVITY INDEX
DIPTERA	0.399	0.343	-0.053	0.023	-0.376
TRICHOPTERA	0.025	0.258	0.233	0.266.	0.241
COLEOPTERA	0.045	0.063	0.036	0.016	-0.029
PLECOPTERA	0.088	0.06	-0.038	0.1719	0.084
EPHEMEROPTERA	0.266	0.292	0.026	0.343	0.077
OLIGOCHAETA	0.03	0.		0	
TURBELLARIA	0.302			0.016	-0.286
MOLLUSCA	0.031	0.083	0.052		
HYDRACARINA	0.019				
COPEPODA	0.002				
COTTIDAE	0.03				
LEPIDOPTERA		0.017		0.106	

TABLE 3.7.3.3.

Tucannon River electivitiy indices for steelhead trout, bull trout, and spring chinook salmon. Benthic macroinvertebrate densities were quantified in the gut and the environment and converted into percentages.

ORGANISM	ENVIRONMENT	STEELHEAD TROUT	ELECTIVITY INDEX	BULL TROUT	ELECTIVITY INDEX
DIPTERA					
Blephariceridae					
Chironomidn	0.196	0.026	-0.17	0.036	-0.161
Chironomid *pupa*	0.196	0.007	-0.19		
Ceratopogonidae	0.003	0.026	0.023		
Empididae		0.02			
Pelecorhychidae		0.033	0.033	0.009	
simuliiw		0.068	0.068	0.063	0.063
Simulidae pupa	0.006				
Tabanidae	0.001				
Tipulidae				0.009	0.009
TOTAL DIPTERA	0.404	0.169	-0.235		-0.298
TRICHOPTERA					
Brachycentridae	0.008			0.000	0.001
Glossosomatidae	0.006	0.033	0.027		
Hydropsychidae		0.013		0.009	
Leptoceridae		0.02			
Limnephilidae		0.071			
Rhyacophilidae		0.007	0.007		
Trichop. pupa	0.013				
TOTAL TRICHOPTERA	0.028	0.143	a.117	0.018	-0.005
COLEOPTERA					
Curculionidae		0.007			
Elmidae larva	0.04				
Elmidae adult				0.009	
Amphizoidae		0.013		0.009	
Amphizoidae pupa				0.009	
TOTAL COLEOPTERA			-0.021	0.026	-0.014
PLECOPTERA					
Chloroperlidae	0.022				
Nemouridae	0.067	0.007	-0.081		
Perlidae	0.009	0.052	0.043	0.071	0.062
Perlodidae					
Pteronarcyidae					
TOTAL PLECOPTERA	0.118	0.058	-0.08		-0.048
EPHEMEROPTERA					
Baetidae	0.07	0.26,	0.189	0.071	0.
Ephemerellidae	0.033	0.013	-0.02	0.053	0.02
Heptageniidae	0.064	0.136	0.072	0.062	-0.002
Leptophlebiidae	0.002				
TOTAL EPHEMEROPTERA	0.169	0.409	0.24	0.186	0.016
OLIGOCHAETA	0.012			0.026	0.014
TURBELLARIA	0.204	.046	-0.159		
MOLLUSCA					
HYDRACARINA	0.027				
COTTIDAE				0.009	
LEPIDOPTERA		0.065		0.08	

TABLE 3.7.3.3. (cont.)

Tucannon River electivitiy indices for spring chinook salmon, 1989. Benthic macroinvertebrate densities were quantified in the gut and the environment and converted into percentages (Bugert et al. 1990).

	ENVIRONMENT	SPRING CHINOOK SALMON	ELECTIVITY INDEX
DIPTERA			
Blephariceridae			
Chironomidae	0.014	0.049	0.036
Chironomid pupa			
Ceratopogonidae			
Empididae			
Pelecorhychidae			
Simulidae	0.002	0.036	0.034
Sciomyzidae	0.002		
Tabanidae			
Tipulidae			
TOTAL DIPTERA	0.018	0.086	0.067
TRICHOPTEAA			
Brachycentridae	0.061		
Glossosomatidae	0.013	0.007	-0.006
Hydropsychidae	0.011		
Leptoceridae			
Limnephilidae	0.002	0.01	0.008
Rhyacophilidae	0.008		
Trichop. pupa			
TOTAL TRICHOPTERA	0.095	.	-0.078
COLEOPTERA			
Curculionidae			
Elmidae larva	0.033	0.046	
Elmidae adult	0.008	0.104	
Amphizoidae			
Amphizoidae pupa			
TOTAL COLEOPTERA	0.101	0.15	0.048
PLECOPTERA			
Chloroperlidae	0.044	Q.014	
Nemouridae			
Perlidae			
Perlodidae	0.112	0.086	
Pteronarcyidae			
TOTAL PLECOPTERA	0.156	0.085	-0.071
EPHEMEROPTERA			
Baetidae	0.063	0.057	-0.006
Ephemerellidae	0.037	0,182	0.166
Heptageniidae	0.082		-0.082
Leptophlebiidae			
TOTAL EPHEMEROPTERA	0.182	0.249	0.067
OLIGOCHAETA	0.057	0.007	-0.05
MOLLUSCA	0.028		o.,
HYDRACARINA	0.002		0
COTTIDAE			
LEPIDOPTERA		0.066	

3.7.4. RANKING OF PREFERRED FOOD ITEMS FOR BULL TROUT, STEELHEAD TROUT, AND SPRING CHINOOK SALMON.

Ephemeroptera, terrestrial invertebrates, Gastropoda, and Trichoptera were the organisms most preferred, in that order, by juvenile rainbow trout in July, 1991, in Mill Creek (see table 3.7.4.1 .). Ephemeroptera, Piecoptera, Diptem, and Cottidae were the organisms most preferred, in that order, by juvenile bull trout in July, 1991, in Mill Creek (see table 3.7.4.2.).

Trichoptera, Ephemeroptera, Diptera, and Plecoptera were the organisms most preferred , in that order, by juvenile steelhead trout in July, 1991, in the Wolf Fork (see table 3.7.4.3.). Trichoptera, Ephemeroptera Plecoptera, and parts were the organisms most preferred, in that order, by juvenile bull trout in July, 1991, in the Wolf Fork (see table 3.7.4.4.).

Ephemeroptera, Plecoptera, Trichoptera, Diptera (tie), and terrestrial invertebrates (tie) were the organisms most preferred,. in that order, by juvenile steelhead trout in July, 1991, in the Tucannon River (see table 3.7.4.5.). Ephemeroptera, Oligochaeta, Piecoptera, and terrestrial invertebrates were the organisms most preferred, in that order, by juvenile bull trout in July, 1991, in the Tucannon River (see table 3.7.4.6.). Coleoptera, Ephemeroptera, and Plecoptera were the organisms most preferred , in that order, by juvenile spring chinook salmon in the summer of 1989, in the Tucannon River (Bugert 1990) (see table 3.7.4.7.).

TABLE 3.7.4.1. **Ranking** of **preferred food items** for juvenile rainbow trout **collected from Mill Creek,** July, **1991.**

RANK	% OCCURRENCE	% NUMBER	% WEIGHT	ELECTIVITY INDEX
1	Nematoda	Nematoda	Gastropoda	Nematoda
2	Ephemeroptera	Ephemeroptera	Ephemeroptera	Ephemeroptera
3	Terrestrials	Terrestrials	Nematoda	Trichoptera

FOOD ITEMS	POINTS	RANK
Nematoda	10	1
Ephemeroptera	a	2
Gastropoda	3	3
Trichoptera	2	4

TABLE 3.7.4.2. **Ranking of preferred food items for juvenile bull trout collected** from **Mill Creek,** July, 1991.

RANK	% OCCURRENCE	% NUMBER	% WEIGHT	ELECTIVITY INDEX
1	Ephemeroptera	Ephemeroptera	Plecoptera	Ephemeroptera
2	Diptera	Plecoptera	Cottidae	Plecoptera
3	Plecoptera	Diptera	Lepidoptera	Trichoptera

FOOD ITEMS	POINTS	RANK
Ephemeroptera	9	1
Plecoptera	a	2
Diptera	3	3
Cottidae	2	4

TABLE 3.7.4.3. Ranking of preferred food items for juvenile steelhead trout collected from the Wolf Fork, July, 1991.

RANK	% OCCURRENCE	% NUMBER	% WEIGHT	ELECTIVITY INDEX
1	Trichoptera	Ephemeroptera	Plecoptera	Trichoptera
2	Ephemeroptera	Trichoptera	Trichoptera	Nematoda
3	Diptera	Diptera	Diptera	Mollusca

FOOD ITEMS	POINTS	RANK
Trichoptera	10	1
Ephemeroptera	5	2
Diptera	3	3
Nematoda	2	4

TABLE 3.7.4.4. Ranking of preferred food items for juvenile bull trout collected from the Wolf Fork, July, 1991.

RANK	% OCCURRENCE	% NUMBER	% WEIGHT	ELECTIVITY INDEX
1	Ephemeroptera	Ephemeroptera	Plecoptera	Trichoptera
2	Plecoptera	Trichoptera	Trichoptera	Plecoptera
3	Trichoptera	Diptera	Unidentified Parts	Ehemeroptera

FOOO ITEMS	POINTS	RANK
Trichoptera	8	1
Ephemeroptera	7	2 (tie)
Plecoptera	7	2 (tie)
Diptera	1	3

TABLE 3.7.4.5. Ranking of preferred food item8 for juvenile steelhead trout collected from the Tucannon River, July, 1991.

RANK	% OCCURRENCE	% NUMBER	% WEIGHT	ELECTIVITY INDEX
1	Plecoptera	Ephemeroptera	Plecoptera	Ephemeroptera
2	Ephemeroptera	Diptera	Terrestrials	Trichoptera
3	Trichoptera	Trichoptera	Trichoptera	Nematoda

FOOD ITEMS	POINTS	RANK
Ephemeroptera	8	1
Plecoptera	6	2
Trichoptera	5	3
Diptera	2	4 (tie)
Terrestrials	2	4 (tie)

TABLE 3.7.4.6. Ranking of preferred food items for juvenile bull trout collected from the Tucannon River, July, 1991.

RANK	% OCCURRENCE	% NUMBER	% WEIGHT	ELECTIVITY INDEX
1	Ephemeroptera	Oligochaeta	Oligochaeta	Ephemeroptera
2	Terrestrial	Ephemeroptera	Plecoptera	Trichoptera
3	Plecoptera	Terrestrials	Diptera	Coleoptera

FOOD ITEMS	POINTS	RANK
Ephemeroptera	8	1
Oligochaeta	4	2
Plecoptera	3	3 (tie)
Terrestrial	3	3 (tie)

TABLE 3.7.4.7. Ranking of preferred food items for juvenile spring chinook salmon collected from the Tucannon River, summer, 1989 (Bugert 1990).

RANK	% OCCURRENCE	% NUMBER	% WEIGHT	ELECTIVITY INDEX
1	Coleoptera	Coleoptera	Coleoptera	Diptera
2	Ephemeroptera	Ephemeroptera	Ephemeroptera	Ephemeroptera
3	Plecoptera	Plecoptera	Plecoptera	Nematoda

FOOD ITEMS	POINTS	RANK
Coleoptera	9	1
Ephemeroptera	8	2
Plecoptera	3	3

3.8 *FISH MOVEMENT AND MIGRATION*

Eighteen adult bull trout were captured in the anadromous fish trap located on the Tucannon River at the Tucannon fish hatchery. One of the 18 tagged bull trout bled immediately from the tag injection wound and was later found dead at the trap. All other tagged fish showed no signs of bleeding or distress and immediately moved upstream following release. Three of the tagged fish (#00041, #00047, and #000215) were caught'by anglers in the Tucannon River. The first two fish were tagged on 3 June, and 5 June,- 1990, and the third fish was tagged on 3 June, 1991. All three fish were tagged at the fish trap (Rk 62.0) and released upstream. Capture dates and river kilometer (Rk) locations were 5 July, 1990 immediately above the Little Tucannon River (Rk 74.5), 14 July, 1990, 0.5 kilometers below the Little Tucannon River (Rk 74.5), and 30 June, 1991 one kilometer up Panjab Creek which enters the Tucannon River at Rk 77.5..

The tagged fish (#00041) moved upstream 12.6 Km in 32 days, the second fish (tag # 00047) moved upstream 12.4 Km in 34 days, and the third fish (tag # 00215) moved upstream 16.5 km in 27 days. The average distance traveled per day was 0.46 Km, with a minimum of 0.36 Km per day and a maximum of 0.61 Km per day.

Another of the tagged fish (# 00463, about 60 cm in total length) was observed constructing a redd immediately below Bear Creek in the Tucannon River (Rk 90) on 6 September 1991. The tag date was 11 June 1991. The fish remained above the hatchery trap for 88 days before spawning, at which time it was observed constructing a redd that was 122 cm wide by 213 cm long. On this redd there were' four other bull trout, with estimated total lengths of 30, 35, 38, and 50 cm. The other 14 tagged fish were not relocated.

No bull trout were captured at the trap in the fall or winter of 1991-92, which indicates that the trap was ineffective at trapping downstream migrating bull trout in the Tucannon River. All fish movement information collected in presented in Appendix F.

3.9 AGE

Data recorded for each fish collected for age determination and values for the average percent error, coefficient of variation, and index of precision are presented in Appendix G.

The average percent error was zero between readings of bull trout otoliths for ages 0 and 1. Average percent error for age 2 bull trout collected from Mill Creek, Wolf Fork, and the Tucannon River was 0, 0.024, and 0 respectively.. The average percent error for age 3 bull trout was 0.017 for Mill Creek, 0.104 for the Wolf Fork, and 0.07 for the Tucannon River. The average percent error for age 4 bull trout was 0.03 for Mill Creek, 0 for the Wolf Fork, and 0.03 for the Tucannon River. The average percent error for age 6 bull trout was 0.088 for Mill Creek, 0 for the Wolf Fork, and 0.024 for the Tucannon River. The average percent error for age 6 bull trout was 0.078 for Mill Creek, 0 for the Wolf Fork, and 0.078 for the Tucannon River.

Prior to making any interstream comparisons of age, .a &-way ANOVA (α = 0.01) of the degree of precision index of age reproducibility was made (Appendix G). This was necessary to make certain that consistency was maintained between streams for the age analysis. The data used in the ANOVA is presented in Appendix G.

A length frequency histogram was constructed for bull trout and steelhead trout collected from each stream to corroborate the age data with (see figures 3.9.1 through 3.9.4). Only data collected in 1991 was used for steelhead trout, but both 1990 and 1991 data was used for bull trout. Using only 1991 data resulted in poor modes in the length frequency histograms due to small sample size. By combining both 1990 and 1991 frequency data, modal peaks became evident in the distribution and therefore allowed differentiation of age classes through the first 3 years (0+ through 2+). This was not necessary for steelhead trout as sample size was large enough to exhibit clear modes in the histogram.

A length-at-age histogram was also construct&d for both bull trout and steelhead trout to allow for visual comparisons of the two age determination methods (see figures 3.9.1 through 3.9.4). Scales were collected from steelhead trout and were used to construct the histograms for this species. Theoretical deliniations of the length frequency histogram have been made by placing brackets around each age distribution in the histogram. Bracket placement was determined by examining modes in the histogram and then by adjusting the placement based on the average fork length for each age class as reported in the length at age histograms.

The mean fork length and range for bull trout as d&mined by the above method, is reported in table 3.9.1 for ages 0+ through 2 + . The 3+ age class was determined by averaging the fork length of all age 3 + bull trout that were reported in Appendix G (otolith method).

The mean fork length and range for steelhead trout as determined by the above method, is reported in table 3.9.2. for ages 0 + through 3 + .

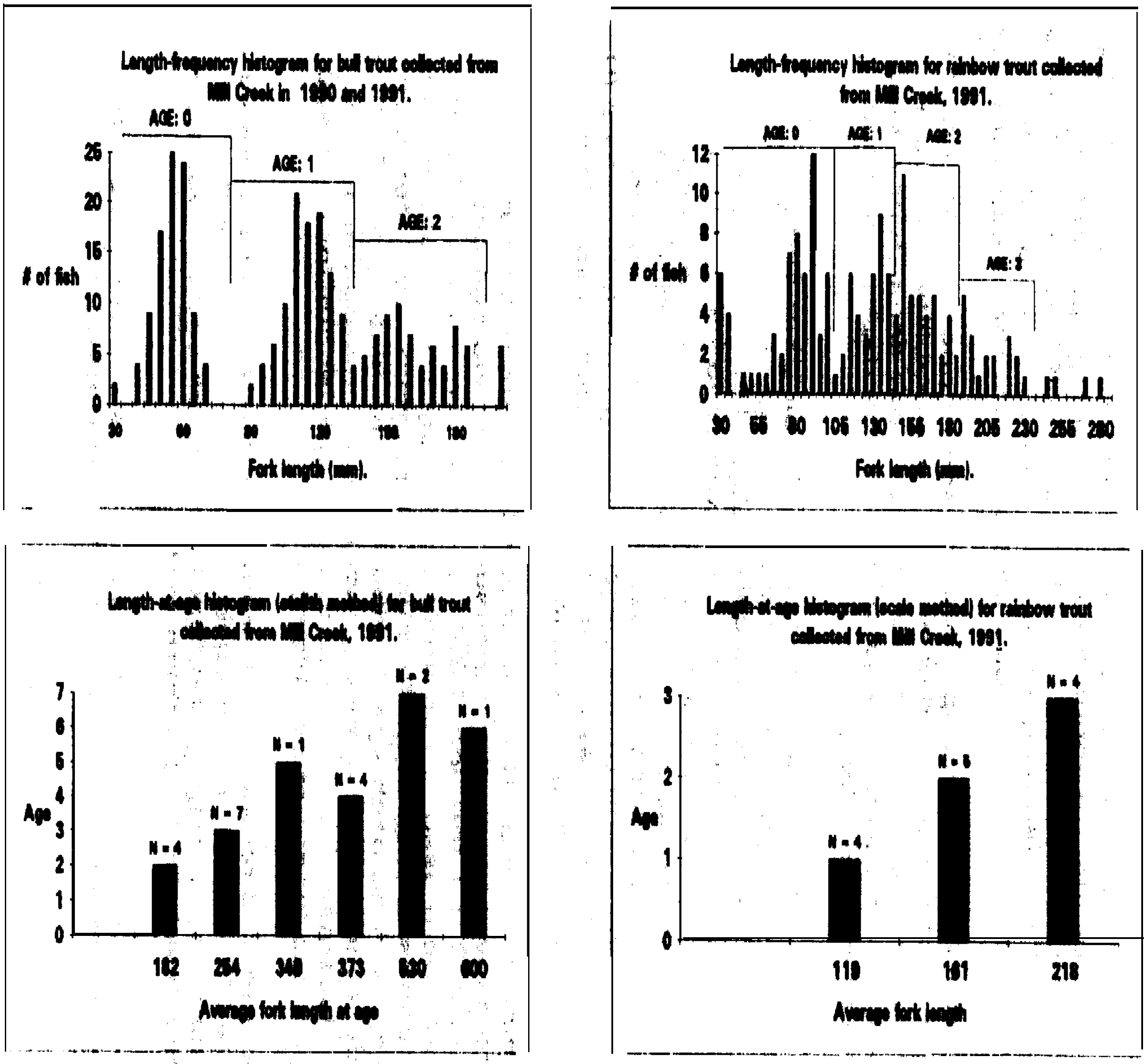

Figure 3.9.1. Length-frequency histogram and length at age histograms for bull trout and rainbow trout collected from Mill Creek, 1991. The length-at-age histogram was constructed with ages determined by the indicated method. The modes in the length-frequency histogram have been deliniated by brackets representative of the length-at-age histogram; the age of the fish in each mode is reported.

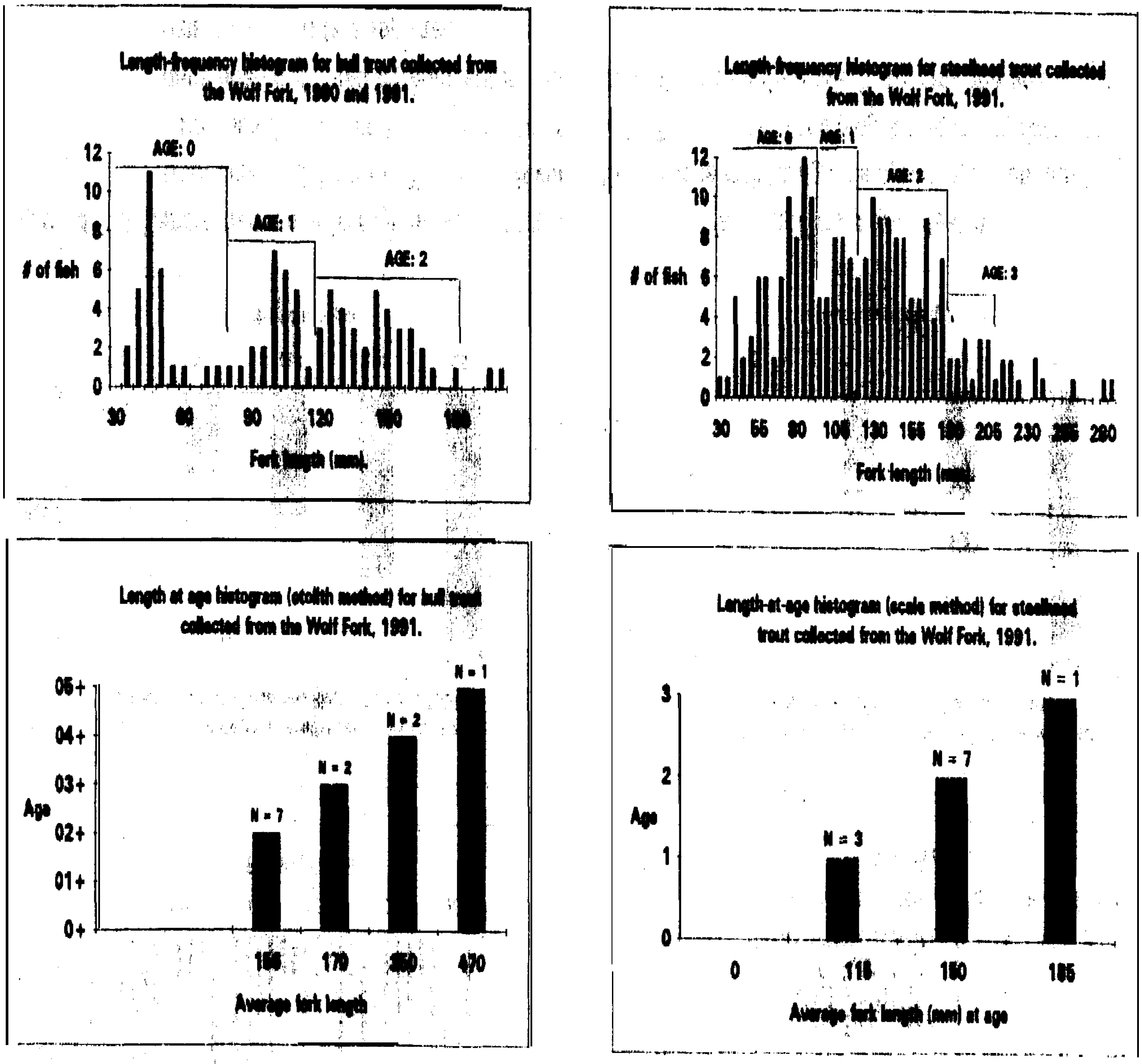

Figure 3.9.2. Length-frequency histogram and length at age histograms for bull trout and steelhead trout collected from the Wolf Fork, 1991. The length-at-age histogram was constructed with age determined by the indicated method. The modes in the length-frequency histogram have been delinlated by brackets representative of the length-at-age histogram; the age of the fish in each mode is reported.

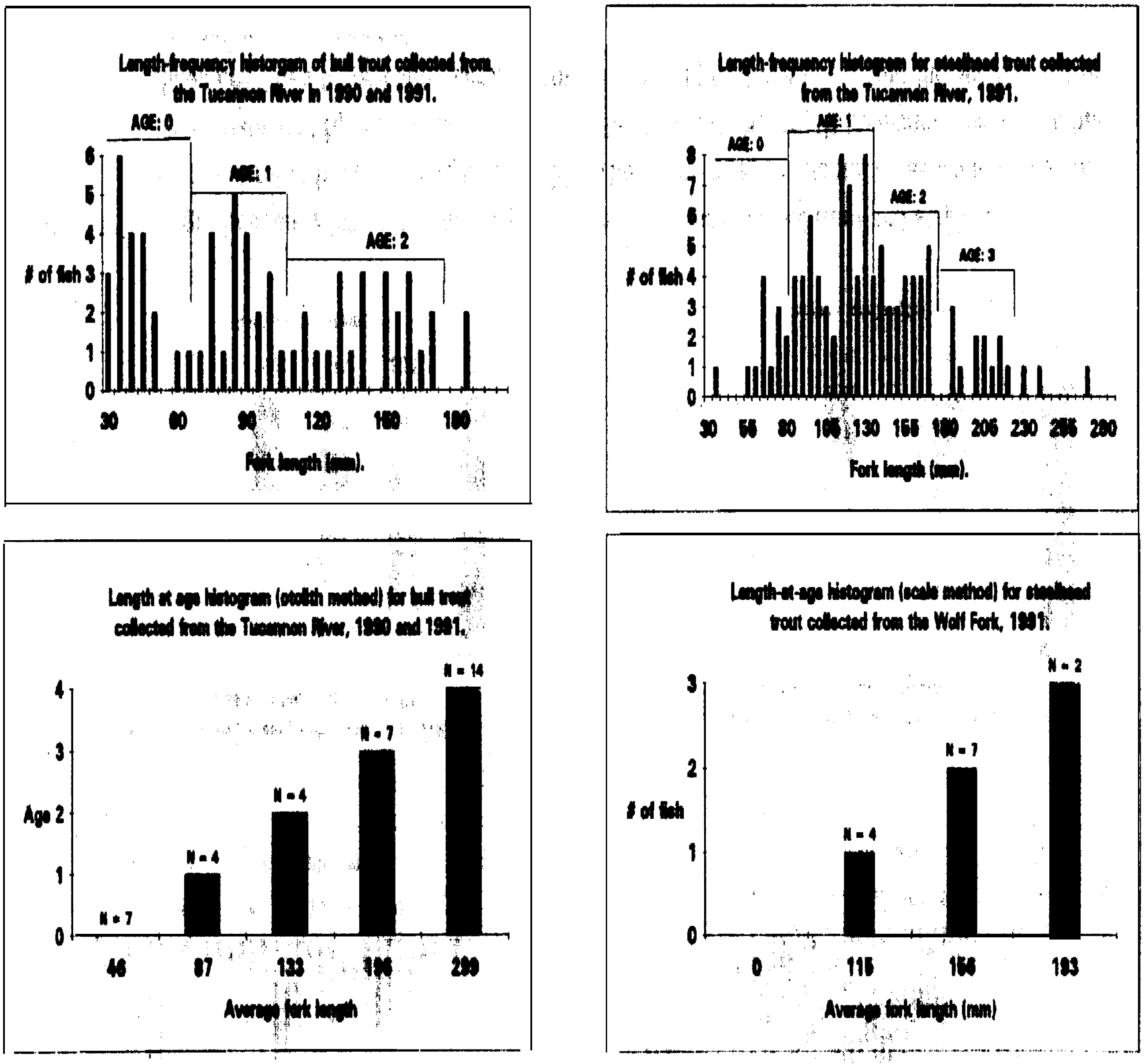

Figure 3.9.3. Length-frequency histogram and length at age histograms for bull trout and steelhead trout collected from the Tucannon River, 1991. The length-at-age histogram was constructed with ages determined by the indicated method. The modes in the length-frequency histogram have been delimiated by brackets representative of the length-at-age histogram; the age of the fish in each mode is reported.

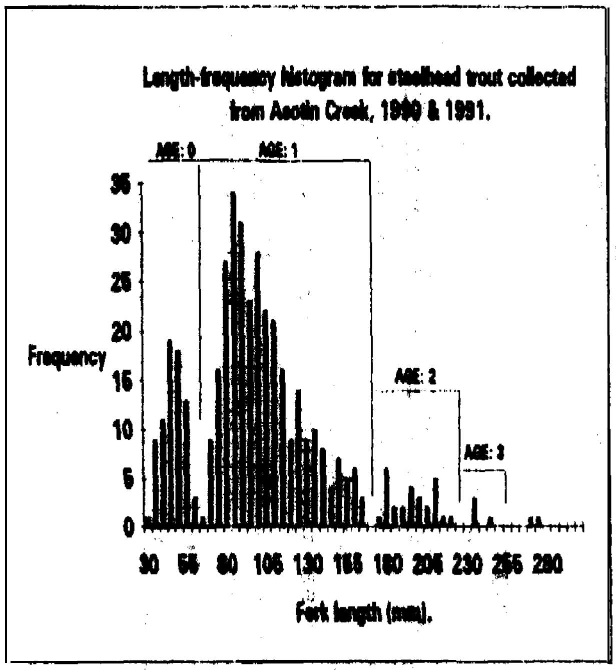

Figure 3.9.4. Length-frequency histogram and length at age histograms for bull trout and steelhead trout collected from Asotin Creek, 1990 & 1991. The length-at-age histogram was constructed with ages determined by the indicated method. The modes in the length-frequency histogram have beendelliniated by brackets representative of the length-at-age histogram; the age of the fish in each mode is reported.

Table 3.9.1. The mean fork length (mm) and range of fork lengths for each age class of bull trout in each stream for 1990 and 1991.

BULL TROUT RIVER	AGE: 0+ MEAN FORK LENGTH (RANGE)	AGE: 1+ MEAN FORK LENGTH (RANGE)	AGE 2+ MEAN FORK LENGTH (RANGE)	AGE: 3+ MEAN FORK LENGTH (RANGE)
Mill Creek	55 (30-70) (n=91)	110 (90-130) (n= 98)	160 (135-190) (n=64)	235 (199-270) (n=5)
Wolf Fork	55 (35-80) (n=26)	105 (85-115) (n=25)	155 (120-185) (n=39)	170 (165-175) (n=2)
Tucannon R.	45 (30-65) (n=21)	90 (70-110) (n=210	145 (115-175) (n=23)	195 (168-225) (n=2)
Asotin Cr.	--	--	163	--

Table 3.9.2. The mean fork length (mm) and mnge of fork length for each age class of steelhead trout and stream for 1 SSO and 1991.

STEELHEAD TROUT RIVER	AGE: 0+ MEAN FORK LENGTH (RANGE)	AGE: 1+ MEAN FORK LENGTH (RANGE)	AGE: 2+ MEAN FORK LENGTH (RANGE)	AGE: 3+ MEAN FORK LENGTH (RANGE)
Mill Creek	70 (30- 100)(n=72)	125 (105-145) (n=41)	170 (160-l 85) (n-41)	210 (190-235) (n=19)
Wolf Fork	65 (30-90) (n=72)	110 (95-1201 (n-391	150 (126-l 75) (n=89)	205 (180-225) (n=20)
Tucannon R.	55 (30-65) (n-13)	110 (70-130) (n=64)	155 (135-l 75) (n=28)	206 (180-225) (n=12)
Asotin Cr.	50 (30-65) (n=75)	120 (70-l 70) (n-311)	200 (176-216) (n=37)	240 (220-250) (n-4)

3.10. CONDITION

Condition factor (Kfl) data, calculated using fork length, was collected from all 'bull trout and steelhead trout captured during electrofishing surveys and stomach Collection. Site specific K(fl) were calculated for both young of the year and juvenile bull trout and steelhead trout. The mean K(fl) for each species was determined for each habitat type to determine habitat specific condition facto& Site specific K(fl) values for adults of both species were excluded from this exercise due to the increased rate of growth in terms of weight after their third year. Wa felt that the presence or absence of adult fish in specific habitat types would skew the data and obscure the results. The mean combined K(fl) for YOY and juvenile age classes for each electrofishing site surveyed on each stream is reported for bull trout and steelhead trout In tables 3.10.1 . through 3.10.4.

Habitat specific condition factors were determined for young of the year and juvenile age classes for both species and reported them in table 3.10.5.

Table 3.10.1. Site specific mean condition factors (Kfl) for each species sampled in Mill Creek, 1991.

SITE #	HABITAT	Mean Kfl (S.D.) Bull Trout	Bull Trout Sample Size	Mean Kfl (S.D.) Rainbow Trout	Rainbow Trout Sample Size
1	*Scour Pool*	1.00 (0.17)	12	1.24 (0.17)	10
2	*Run*	1.01 (0.01)	4	-	
3	*Riffle*	1.19 (0.30)	21	1.09 (0.08)	3
4	*Cascade*	-		-	
5	*Plunge Pool*	-		-	
6	*Scour Pool*	1.02 (0.12)	8	1.07 (0.22)	15
7	*Riffle*	0.94 (0.22)	17	1.25 (0.17)	9
8	*Cascade*	1.03 (0.10)	20	1.28 (0.35)	11
9	*Riffle*	1.01 (0.09)	18	1.16 (0.14)	6
[redacted]	*Cascade*	1.05 (0.08)	11	1.15 (0.11)	5
[redacted]	*Run*	1.06 (0.08)	5	1.41	1
12	*Scour Pool*	1.12 (0.10)	7	1.24 (0.11)	7
13	*Riffle*	1.17 (0.13)	13	1.19 (0.10)	8
14	*Plunge Pool*	1.06 (0.07)	5	1.23 (0.05)	4
15	*Cascade*	0.98 (0.02)	3	1.17 (0.29)	11
16	*Run*	0.78 (0.39)	2	1.16 (0.09)	9
17	*Plunge Pool*	*0.94* (0.03)	3	1.07 (0.24)	20
18	Rime	1.01 (0.06)	5	1.25 (0.13)	11
19	scour Pool	-		1.17 (0.07)	11

Table 3.10.2. Site **specific** mean condition factors (Kfl) for each species sampled In the Wolf Fork, 1991.

SITE #	HABITAT	MEAN Kfl (S.D.) Bull Trout	Bull Trout Sample Size	MEAN Kfl (S.D.) Steelhead Trout	Steelhead Trout Sample Size
1	*Scour Pool*	1.01 (0.04)	4	1.26 (0.05)	-
2	Run	*1.06* (0.44)	6	1.34 (0.061	4
3	*Riffle*	1.11 (0.40)	11	1.34 (0.10)	3
5	*Plunge* Pool	0.82 (0.02)	3	1.27 (0.15)	3
6	*Plunge* Pool	1.12	1	1.33 (0.13)	11
7	*Cascade*	1.08 (0.051	4	1.24 (0.14)	11
a	Run	1.22 (0.30)	2	1.29 (0.14)	13
9	*Riffle*	.08	6	1.16 (0.11)	10
10	*Scour Pool*	1.17 (0.05)	3	1.26 (0.10)	23
11	*Scour Pool*	1.18 (0.11)	11	1.38 (0.24)	3
12	Rime	1.30	1	1.13 (0.42)	6
13	cascade	--		1.2 (0.121	8
14	*Run*	1.25	1	1.18 (0.10)	17
15	*Plunge,* Pool	-			
16	*Plunge Pool*	-		1.04 (0.15)	4
17	*Scour Pool*	-		1.21 (0.19)	38
18	*Run*	1.01	1	1.19 (0.19)	18
19	*Riffle*	.		1.17 (0.141	12
20	*Cascade*	.		1.25 (0.12)	12

Figure 3.10.3. Site specific mean condition factors (Kfl) for each species sampled in the Tucannon River, 1991.

SITE #	HABITAT	MEAN Kfl (S.D.) Bull Trout	Bull Trout Sample Size	MEAN Kfl (S.D.) Steelhead Trout	Steelhead trout Sample Size
1	*Cascade*	0.98 (0.10)	3	0.98 (0.22)	5
2	*Run*	0.92 (0.30)	6	1.14	1
3	*Plunge Pool*	0.99	1	1.19 (0.25)	4
4	*Scour Pool*	0.98 (0.08)	5	1.18 (0.04)	4
5	*Riffle*	1.17 (0.37)	3	1.22 (0.12)	6
6	*Riffle*	-		-	
7	*Plunge Pool*	1.1	1	1.19 (0.13)	9
8	*Run*	0.96 (0.04)	2	1.16 (0.07)	5
9	*Cascade*	0.9	1	1.14	1
10	*Scour Pool*	1.11 (0.20)	4	1.21 (0.08)	6
11	*Run*			1.21 (0.10)	4
12	*Scour Pool*	1.02 (0.08)	5	1.17 (0.09)	6
13	*Riffle*	0.97 (0.02)	6	-	
14	*Cascade*	1.27 (0.02)	2	1.18	1
15	*Plunge Pool*	1.05 (0.13)	3	1.12 (0.17)	8
16	*Run*	1.11 (0.21)	5	1.19 (0.05)	17
17	*Riffle*	1.89	1	1.21 (0.20)	3
18	*Plunge Pool*	1.06	1	1.15 (0.04)	5
19	*Cascade*	0.9 (0.29)	4	1.14 (0.16)	3
20	*Scour Pool*	1.01 (0.10)	4	1.27 (0.12)	9

Figure 3.10.4. Site specific mean condition factors (Kfl) for each species sampled in Asotin Creek, 1991.

SITE #	HABITAT	MEAN Kfl Bull Trout	MEAN Kfl (S.D.) Steelhead Trout	Steelhead Trout Sample Size
0.5	*Plunge Pool*	---	1.18 (0.12)	n = 17
1	*Cascade*	---	1.18 (0.12)	n = 17
2	*Plunge Pool*	---	1.17 (0.07)	n = 17
3	*Riffle*	---	1.59 (0.64)	n = 17
4	*Scour Pool*	--	1.45 (0.10)	n = 9
5	*Run*	---	1.11 (0.14)	n = 11

Table 3.10.5. **Mean** habitat **specific condition factors for young-of-the-year** ad **juvenile bull trout and steelhead trout** for **each** of the 4 study **streams, 1991. Sample size (n) is also reported.**

MILL CREEK

HABITAT TYPE	BULL TROUT	STEELHEAD TROUT
Plunge Pool	1.01 (n = 8)	1.15 (n = 24)
Scour Pool	1.04 (n = 27)	1.18 (n = 43)
Run	1.04 (n = 16)	1.19 (n = 10)
Riffle	1.07 (n = 37)	1.21 (n = 37)
Cascade	1.03 (n = 34)	1.21 (n = 27)

WOLF FORK

HABITAT TYPE	BULL TROUT	STEELHEAD TROUT
Plunge Pool	1.08 (n = 3)	1.31 (n = 15)
Scour Pool	1.14 (n = 18)	1.24 (n = 67)
Run	1.11 (n = 9)	1.22 (n = 52)
Riffle	1.12 (n = 17)	1.18 (n = 29)
Cascade	0.95 (n = 7)	1.20 (n = 34)

TUCANNON RIVER

HABITAT TYPE	BULL TROUT	STEELHEAD TROUT
Plunge Pool	1.04 (n = 4)	1.16 (n = 26)
Scour Pool	1.03 (n = 18)	1.22 (n = 26)
Run	1.0 (n = 14)	1.19 (n = 27)
Riffle	1.12 (n = 10)	1.22 (n = 9)
Cascade	1.0 (n = 10)	1.07 (n = 10)

ASOTIN CREEK

HABITAT TYPE	BULL TROUT	STEELHEAD TROUT
Plunge Pool	---	1.18
Scour Pool	---	1.46
Run	---	1.13
Riffle	---	1.59
Cascade		1.18

3.11. GROWTH

Changes in weight in relationship to length were plotted on a graph and eye-fitted regression lines were drawn through the points representing ages 0+ through 2 + , and year classes beyond 2 + for all bull trout collected (Fig. 3.11 .1.). The length at age 2 + values were reported in section 3.10 Age, for bull trout and were used in this exercise. The data used to quantify changes in weight with length is presented in Appendix I. .

The longest (fork length), age 2 + bull trout collected from each stream was 1 90mm, 180mm, and 170 mm, for Mill Creek, Wolf Fork, and the Tucannon River, respectively. At age 2 (third. summer of growth) the fish show an accelerated increase in weight with respect to length in each of the study streams.

The slope of the regression line drawn through the length-weight data for each life stage of bull trout shows that through their third summer of growth, bull trout weight increases at a rate of 0.59 in Mill Creek, 0.44 in the Wolf Fork, and 0.51 in the Tucannon River (see figure 3. 11.1.). From this data we infer that "through their third summer of growth, the weight of bull trout in Mill Creek increases at a faster rate in relationship to length than in the Wolf Fork or Tucannon River. .

The slope of the regression line drawn through the length-weight data for bull trout oldet than 2 + , shows that weight increases at a rate of 2.36 in Mill Creek, 1.36 in the Wolf Fork, and 2.20 in the Tucannon River (see figure 3.11.1 .). From this data we infer that after their third summer of growth, the weight of bull trout in Mill Creek increases at a faster rate in relationship to length than in the Wolf Fork or Tucannon River, but acknowledge that the amount of data for these older fish is limited in each river.

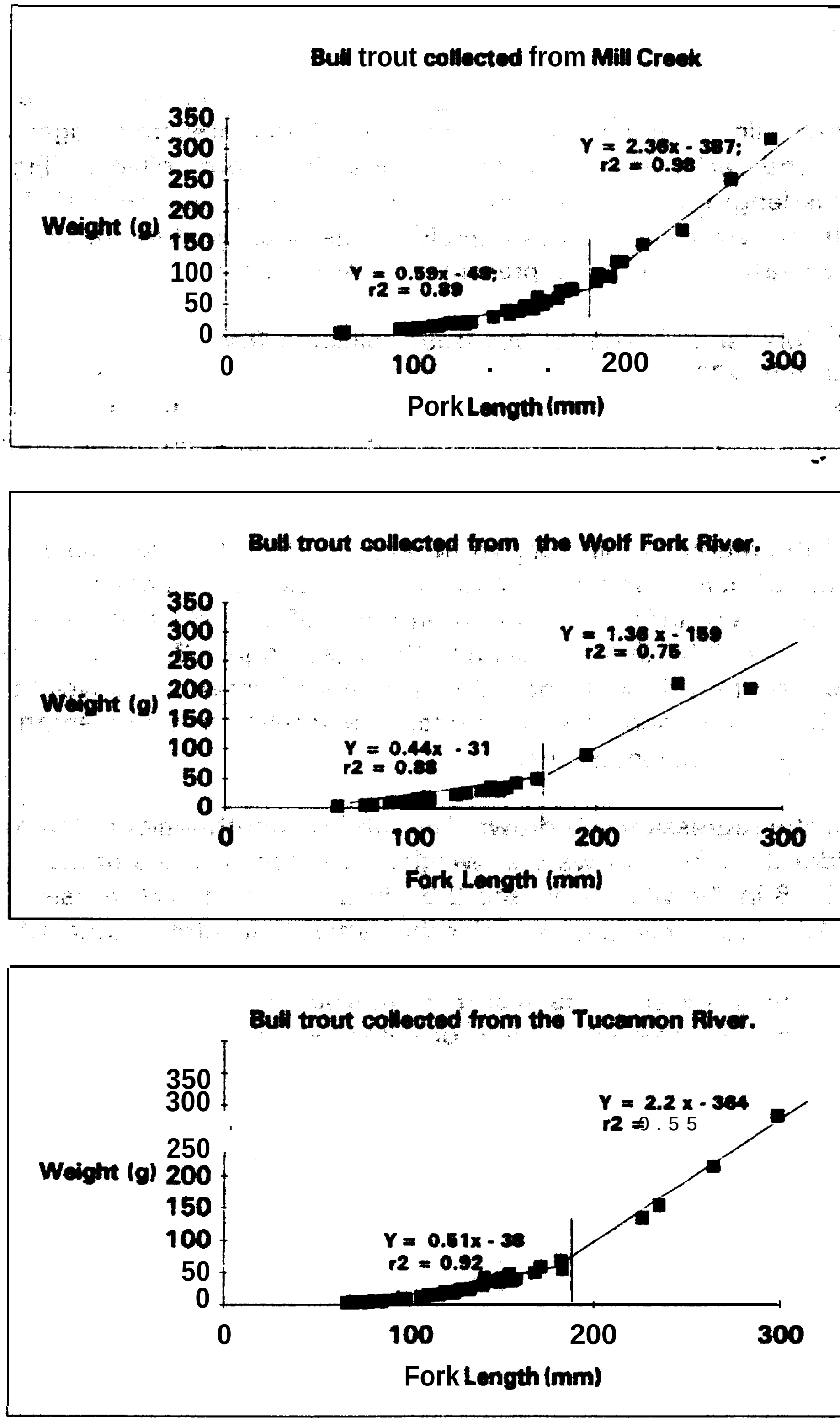

Figure 3.11 .1 Weight-length relationships for bull trout collected from each of the study streams in 1991. The regression lines have been fitted by eye.

3.12. ***SPAWNING*** GROUND ***SURVEYS***

Stream distances of 6.3, 5.1, and 7.1 river kilometers were surveyed in Mill Creek, Wolf Fork, and the Tucannon River, respectively, for bull trout redd construction. The survey reaches include all bull trout spawning areas in each stream, including tributaries. Redds were easily identified by their typical morphology and recently cleansed gravel. The same reach of each stream was surveyed in 1990 and 1991 except for 2.2 kilometers in the Tucannon River (see appendix J, for temporal and spatial distribution of bull trout redds in each of the study streams for 1990 and. 1991). This 2.2 kilometers of river was not surveyed in 1990 until November 8, well after all other surveys were concluded. Thirty eight redds were observed prior to November 8th on the Tucannon River. This compared poorly to the 66 and 49 redds observed in Mill Creek and the Wolf Fork, respectively. With this Information we felt that the fish had not yet spawned or that we had not ascended the stream far enough to find them (the latter was the case), The year end total number for the Tucannon River included the 22 redds observed after November 8th, and therefore appears to be misleading.

The following tables (Tables 3.12.1. and 3.12.2.) report the adjusted survey date and the number of redds observed on that adjusted date, as well as the year-&d total number of redds. The adjusted survey date is rep&ted due to individual stream survey dates differing (we couldn't survey 3 streams in one day). For a complete list of the redd number, stream location, landmark proximity, and survey date refer to appendix J. Appendix J also reports the number and date of spring chinook salmon. redd construction in the Tucannon River for 1991, as well as the mean number and location of redds in the Tucannon River for 1985 through 1991 (Mendel, WDF personal communication 1991).

3.13. ***REDD CHARACTERIZATION***

The average length and width for bull trout redds constructed in Mill Creek were 1.62 and 0.87 meters, respectively in 1'990, and 1.58 and 0.82 meters, respectively in 1 991. The average length and width for bull trout redds constructed in the Wolf Fork were 1.37 and 0.67 meters, respectively in 1990, and 1.98 and 6.86 meters, respectively in 1991. The average length and width for bull trout redds constructed in the Tucannon River were 1.62 and 1.05 meters, respectively in 1990, and 1.90 and 0.87 meters, respectively in 1991 .The average bull trout redd surface area was 1 Al m^2 (1 990 Mill Creek), 0.92 m^2 (1996 Wolf Fork),, 1.70 m^2 (1990 Tucannon River), 1.30 m^2 (1991 Mill Creek), 1.70 m^2 (1991 Wolf Fork), and 1.65 m^2 (1991 Tucannon River) (See tables 3.13.1. and 3.13.2.).

Table 3.12.1. Spawning ground survey date, number of redds observed on survey date and density (#/Km), and year-end total number of redds constructed bybuii trout in each stream, 1990.

RIVER	9/5	9/11	9/20	9/27	10/3	10/9	10/26	11/8	TOTAL
Mill Creek	0(0)	0(0)	32(5.1)	16(2.5)	--	18(2.9)	0(0)	0(0)	66(10.5)
Wolf Fork	9(1.8)	11(2.2)	9(1.8)	9(1.8)	9(1.8)	2(0.4)	0(0)	0(0)	49(9.6)
Tucannon R.	0(0)	0(0)	9(1.3)	9(1.3)	3(0.4)	3(0.4)	8(1.1)	5(0.7)	60(8.5)

Table 3.12.2. Spawning ground survey data, number of redds and density (#/Km)observed on survey date (density), and year-end total number of redds constructed by bull trout in each stream, 1991.

RIVER	9/6	9/14	9/23	10/5	10/15	total
Mill Creek	10 (1.6)	12 (1.9	12 (1.9)	8 (1.3)	11 (1.7)	55 (8.7)
Wolf Fork	14 (2.7)	18 (3.5)	8 (1.6)	13 (2. 5)	3 (0.6)	56 (11.0)
Tucannon R.	7 (1.0)	15 (2.1)	22 (3.1)	4 (0.6)	9 (1.3)	57 (8.0)

The average water depth in the bowl of each' of the characterized bull trout redds was 0.25 m, 0.31 m, and 0.21 m -in Mill 'Creek, the Wolf Fork, and the Tucannon River for 1990, respectively. Year to year comparisons of substrate utilization can not be 'made bacause we changed the substrata size classes for 1991. In 1990, substrate utilized in the bowl was mainly 0.1 to 1 inch (0.04 to 2.54 cm) in diameter for all 3 streams; 50%, 38% and 40 % for Mill Creek, Woif Fork, and the Tucannon River, respectively. in 1991, substrate utilized in the bowl was mainly 1/2 to 2 1/2 inches (cobble) (1.27 to 6.35 cm) in diameter for all 3 streams; 35%, 42%, and 38% for Miii Creek, W&f Fork, and the Tucsnnon River, respectively (See tables 3.13.1. and 3.13.2.).

in 1990, substrate utilized in the tall was mainly 0.1 to 1 inch in (0.04 to 2.54 cm) diameter for all 3 streams; 61%, 44%, end 42% for Mill Creek, Wolf Fork, 'and the Tucannon River respectively. in 1991 substrate utilized in the tail was mainly 1/2 to 2 1/2 inches (cobble) (1 .27 to 6.35 cm) in diameter for all 3 streams; 56%, 43%, and 61%, for Mill Creek, Wolf Fork, and the Tucannon River, respectively (See tables 3.15.1. and 3.13.2-L

Bull trout redd location in both 1990 and 1991 was almost exclusively in run habitat; 58% & 90%, 91% & 79%, and 100% & 85%, for Mill Creek, Wolf fork, and the Tucannon River in 1990 and 1991, respectively. The remaining redds in each stream were located in the tail section of pools (See tables 3.13.1. and 3.13.2.).

The proximity to hiding cover varied greatly from redd to redd and stream to stream; bull trout seemed to use what was available. However, overhanging vegetation was the predominant type of hiding cover for bull trout redd location. The average distance to overhanging vegetation from the redd was 0.74, 0.93, and 0.96 meters for Mill Creek, Wolf Fork, and the Tucannon River, respectively in 1990. -The average distance in 1991 was 0.26, 0.84, and t.49 meters, for Mill Creek, Wolf Fork, and the Tucannon River, respectively (See tables 3.13.1. and 3.13.2.). The summarized 1990 and 1991 redd characterization data can be found in tables 3.1 3.1 and 3.13.2, respectively.

Table **3.13.1. Physical characteristics** of **every third bull trout redd** in **each stream (1990),** values are **averages (standard deviation):**

PARAMETER	**Wolf Fork** (n = 11)	**Mill Creek** (n = 12)	**Tucannon R.** (n = 5)
DIMENSION Length (m)	1.37 (.52)	1.62 (.41)	1.62 (.23)
Width (m)	0.67 (.19)	.87 (.39)	1.05 (.23)
WATER DEPTH Bowl(m)	.26 (.13)	.31 (.06)	.21 (.03)
Tail (m)	.2 (.02)	.15 (.04)	.09 (.01)
Side (m)	.2 (.09)	.23 (.06)	.14 (.03)
BOWL SUBSTRATE			
.1 - 1 inch	38% (.22)	50% (.18)	32% (.07)
1 - 2 inch	15% (.09)	13% (.08)	16% (.08)
2 - 3 inch	16% (.11)	10% (.08)	12% (.07)
3 - 4 inch	26% (.16)	28% (.11)	40% (.17)
TAIL SUBSTRATE			
.1 - 1 inch	44% (.21)	61% (.18)	42% (.09)
1 - 2 inch	32% (.14)	18% (.10)	48% (.08)
2 - 3 inch	15% (.10)	8% (.07)	9% (.13)
3 - 4 inch	9% (.08)	14% (.12)	2% (.06)
HABITAT TYPE	10 of 11 = run 1 of 11 = Tail of Pool	7of 12 = fun 5of 12 = Tail of Pool	5 of 5 = run
PROXIMITY TO COVER (m)			
Deep (>30 cm)	0.95	0.77	--
Overhanging vegetation	0.93	0.74	0.96
Large organic debris	1.02	0.72	1.68
Undercut bank	0.78	0.75	
Turbulence	1.44	1.20	

Table 3.13.2. Physical characteristics of every third bull trout redd in each stream (1991), values are averages (standard deviation):

PARAMETER	Mill Creek n = 10	Wolf Fork n = 14	Tucannon R. n = 13
DIMENSION Length (m)	1.58 (.67)	1.98 (.80)	1.90 (.71)
Width (m)	0.82 (.19)	.86 (.44)	0.87 (.33)
WATER DEPTH Bowl (m)	0.28 (.05)	.53 (.46)	0.20 (.06)
Tail (m)	0.16 (.05)	.16 (.11)	0.10 (.05)
Side (m)	0.21 (.04)	.32 (.22)	0.16 (.06)
SUBSTRATE Bowl			
< 1/8	18% (.11)	7% (.16)	7% (.60)
1/8 - 1/2	29% (.13)	28% (.23)	34% (.22)
1/2 - 2 1/2	35% (.18)	42% (.19)	38% (.18)
2 1/2 - 10	16% (.13)	22% (.16)	22% (.15)
Bedrock	0 (0)	1% (.03)	0 (0)
Tail			
< 1/8	60% (.80)	3% (.06)	2% (.04)
1/8 - 1/2	24% (.20)	41% (.21)	29% (.15)
1/2 - 2 1/2	56% (.26)	43% (.16)	61% (.16)
2 1/2 - 10	14% (.12)	13% (.11)	9% (.08)
Bedrock	0% (0)	0 (0)	0 (0)
HABITAT TYPE	9 of 10 = Run 1 of 10 = Tail of Pool	11 of 14 = Run 3 of 14 = Tail of Pool	11 of 13 = Run 2 of 13 = Tail of Pool
PROXIMITY TO COVER (m)			
Deep (>30 cm)	0.71	0.93	1.88
Overhanging vegetation	0.26	0.64	1.49
Large organic debris	0.59	1.65	1.52
Undercut bank	1.33	1.23	1.47
Turbulence	1.48	1.82	1.89

*3.74. **STREAM** TEMPERATURE DATA*

In general, summer (June through September) stream temperatures increased steadily until the third week in August and then began to fall. Thermal regimes were similiar between streams except that the Tucannon River was consistently 2 to 4 Co warmer than Aaotin Creek, while Aaotin Creek was consistently 1 to 3 Co warmer than Mill Creek. The temperature data recorded in the Wolf Fork from 24 August through 20 September, 1991, showed that this stream was almost uniform to Mill Creek in its temperature regime (Figure 3.14.1 .).

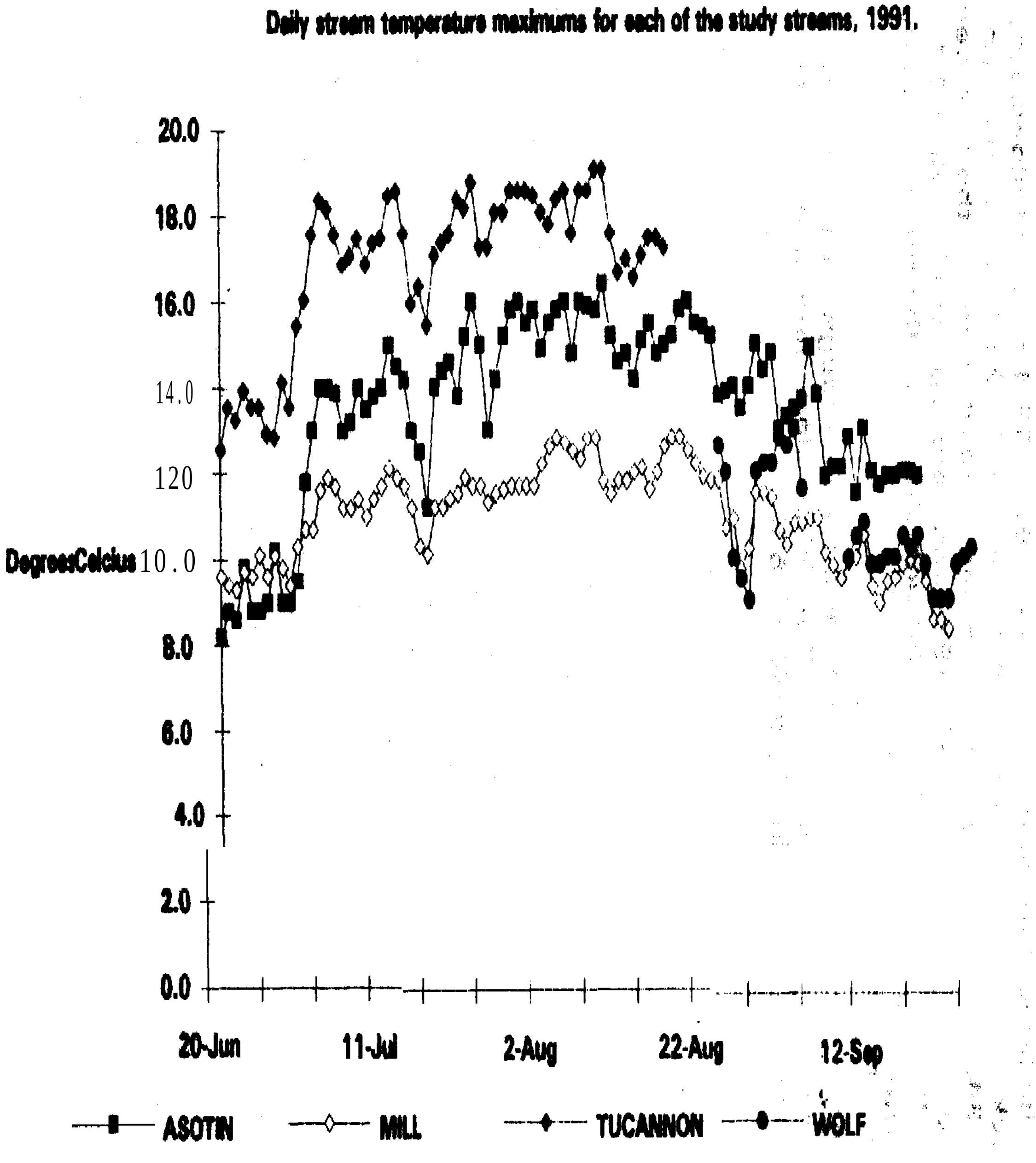

Figure 3.14.1. Summer maximum daily stream temperatures for Asotin Creek, Mill Creek, Tucannon River, and the Wolf Fork, 1991.

3.75. STREAM FLOW DATA

Stream flow was determined at 3 of the 6 habitat inventory segments in each stream. Flow data, reported for the highest (#1), lowest (#6), and middle habitat inventory segment (#3 or #4), showed that the Tucannon River was the largest in terms of volume (76.7 - 39.4 c.f.s.), followed by Asotin Creek (46.2 - 37.1 c.f.s.), Mill Creek (39.6 - 26.1 c.f.s.), and the Wolf Fork (34.0 - 5.0 c.f.s.). These values were recorded in the last week of 'June and the first week of July, 1991, and are reported in tables 3.15.1 through 3.15.4. (See figures 2.2.1. through 2.2.5. for the habitat inventory segment locations in each stream).

Flows were taken at various locations and times throughout the summer sampling period in each tributary. These times, flow, and location were recorded and are reported in the table 3.15.5.

Table 3.15.1. Mill Creek habitat inventory segment flow data, 1991.

SEGMET #:	#1	#4	#6
DATE:	7/11	7/15	7/15
FLOW (cfs):	22.0	24.95	42.3

Table 3.15.2. Wolf Fork habitat inventory segment flow data, 1991.

SEGMET #:	#1	#3	#5	#6
DATE:	6/25	7/1	7/1	6/25
FLOW (cfs):	5.0	14.84	24.32	34.0

Table 3.15.3. Tucannon River habitat inventory segment flow data, 1991.

SEGMET #:	#1	#3	#4	#6
DATE:	6/27	7/1	6/27	7/1
FLOW (cfs):	39.4	45.48	57.46	76.7

Table 3.15.4. Asotin Creek habitat inventory segment flow data, 1991 .

SEGMR #:	#1	#3	#4	#6
DATE:	7/3	7/3	712	7/2
FLOW (cfs):	46.20	51.25	60.29	37.07

Table 3.15.5. Stream flow data reported for the listed date, stream and location, 1991.

DATE	STREAM	FLOW (c.f.s.)	LOCATION	RIVER Km.
7/1/1991	Wolf Fork	24.32	RK 13.1	13.1
7/10/91	wolf Fork	20.30	RK 13.1	13.1
10/10/91	wolf Fork	1.17	U.S.F.S. boundary	19.2
7/16/91	Wolf Fork	08.32	Electro. site #1	17.0
10/10/91	Wolf Fork	10.56	Electra. site #8	14.7
10/28/91	Tucannon R.	07.19	Above Sheep Cr.	85.0
7/1/91	Tucannon R.	45.48	1.8mi above PanJab Cr.	77.6
7/3/91	Asotin	61.26	USFS fence	34.0
8/20/91	Asotin	10.25	above south Fork	23.5
7/11/91	Mill Creek	22.31	@N. Fk Trail	2914
8/20/91	Asotin	15.15	Below south fork	23.3

4.0 DISCUSSION

I. MEASUREMENTS OF SPECIES INTERACTION

4.1. STREAM HABITAT MEASUREMENT

The four study streams were physically simillar in the inventoried reach, 8s determined by stream habitat measurements (see tables 3.3.1 through 3.3.5.). Asotin Creek differed in the amount of overhead cover @resent, probably because of extreme flood events that occurred in the 1960's and 1970's. Floods also damage spawning end rearing habitat. Marnell (1984) reported that devastating floods occurred in Glacier National Park in 1 964 and again in 1975 which caused widespread damage to natural stream channels including spawning and rearing habitat.

Flooding, which causes the removal of large woody debris, necessary in plunge pool formation, may also be the reason that there were fewer plunge pools observed in Asotin Creek (table 3.2.5), as compared to the Tucannon River and the Wolf fork. The low numbers of plunge pools observed in Mill Creek, we believe, may be attributed to a lack of log recruitment.

Run habitat contained 69% cobble substrate in Asotin Creek, this was the highest in any of the study streams. Bull trout spawn in run habitat and use cobble substrate. It appears that spawning habitat is good to excellent in this stream, and therefore is not the reason for low numbers of bull trout in this stream.

Table 4.1.1. was created to allow for comparisons of each of the biological indices of competition that were gathered in this study. The remainder of the discussion section witl be focused around this table.

Table 4.1-1. Information used to determine potential competitive interactions between bull trout, steelhead trout, and spring chinook salmon in southeast Washington streams (B.T. = bull trout, STHD = steelhead trout, and SCS = spring chinook salmon).

RIVER	BULL TROUT HARVEST
Mill Cr.	No harvest
Wolf Fk.	Difficult access - little harvest
Tucannon	Easy access - high harvest
Asotin Cr.	Difficult access - little harvest

RIVER	LAND USE - STREAM DISTURBANCE
Mill Cr.	No disturbance - pristine
Wolf Fk.	Little disturbance - cattle,human
Tucannon	Moderate disturbance - cattle,human
Aeotin Cr.	Little disturbance - logging,flooding

DENSITY ($\#/100m^2$) ALL AGES INCLUDED

RIVER	B.T.	STHD	SCS
Mill Cr.	13.4	7.5	--
Wolf Fk.	9.2	11.6	--
Tucannon	5.4	6.3	0.5
Asotin Cr.	0.1	42.8	0

RELATIVE ABUNDANCE ($\#/100m^2$)

RIVER	B.T.	STHD	SCS
Mill Cr.	0.06	0.21	
Wolf Fk.	0.06	0.76	--
Tucannon	0.12	0.50	0
Asotin Cr.	0	0.24	0.70

HABITAT PREFERENCE

RIVER	B.T.	STHD	SCS
Mill Cr.	Plunge*	Plunge	--
Wolf Fk.	Scour	Scour	--
Tucannon	Scour	Scour	Scour
Asotin Cr.	Cascade	Scour	--

* Plunge = Plunge Pool
Scour = Scour Pool

FOOD PREFERENCE

RIVER	B.T.	STHD	SCS
Mill cr.	Ephem.*	Nematoda	--
Wolf Fk.	Trichop.	Trichop.	--
Tucannon	Ephem.	Ephem.	Coleop.
Asotin cr.	--	--	--

* Ephem = Ephemeroptera (mayfly)
Trichop = Trichoptera (Caddisfly)
Coleop = Cdsoptera (Beetle)

BULL TROUT GROWTH RATE

RIVER	JUVENILE	ADULT
Mill cr.	0.59	2.30
Wolf Fk.	0.44	1.36
Tucannon	0.51	2.20
Asotin Cr.	--	

CONDITION FACTOR

RIVER	B.T.	STHD	SCS
Mill Cr.	1.04	1.19	
Wolf Fk.	1.10	1.23	
Tucannon	1.04	1.17	
Amotin Cr.	0	1.31	

4.2. BULL TROUT HARVEST AND LAND USE - STREAM DISTURBANCE

Entrance in to the Mill Creek watershed is prohibited by law, and therfore harvest of bull trout does not occur in this stream. The harvest of adult bull trout in each of the other study streams is regulated by WDW (the regulations were presented in section 1.3). it is difficult to determine the number of adult bull trout harvested in these streams due to the remoteness of the fishery and a lack Of creel date. However it is estimated that harvest is greatest in the Tucannon River due to this stream's relatively easy access and high fisherman visits (Mark Schuck personal communication).

Harvest of adult bull trout in the Wolf Fork River is less than the Tucannon River because this stream flows through private land and angler access is strictly regulated by local landowners. Harvest Of adult bull trout in Asotin Creek has been reported by local residents. However due to the low number of adults captured in this study and the absence of. anglers during the summer of 1990 and 1991, harvest is speculated as being quite low in this stream.

Due to Mill Creek's protection to human entrance, there has been no land use or stream disturbance in this stream, and therfore it is defined as pristine. The Wolf Fork River's watershed is currently grazed by cattle and there are small cabins and summer homes located along it's floodplain. The disturbance, currently, to this stream is very limited. The Tucannon River currently has the greatest land us8 and stream disturbances of any of the study streams. The land uses include a maintained road, horseback trail, . . maintained camping sites and outhouses, and cattle grazing. The stream disturbances include cattle grazing, removal of riparian vegetation by campers, and human disturbance at the time of spawning.

Asotin Creek has seen recent and severe floods since the 1960's and, therefore we have included flooding as a stream disturbance as it is reported that flooding removes streamside logs and results in a decreased number of pools. The Asotin Creek watershed is owned by the United States Forest Service and is currently being logged. The only other land uses include cattle grazing, camping, horseback riding, and motorcycles. Stream disturbances include cattle grazing and sediment input from runoff of the logged watershed, and recent floods.

The land use and stream disturbances varied greatly between streams. Use and disturbances were reported to show that there were other interstream differences than species present.

4.3. POPULATION ESTIMATES / DENSITY

Bull trout densities in the study reach of each stream varied greatly. Species interactions would be expected to be greatest where there are the moat organisms present per unit area. Bull trout density was highest in Mill Creek followed by the Wolf Fork, Tucannon River, and Asotin Creek (Table 3.3.2. - Density). Bull trout density is less in the streams that receive supplementation, as compared to the control stream, possibly due to higher steelhead trout densities in these streams. tf the fish are competing for food or space, a direct result may be reduced density in the affected streams.

It was difficult to capture young of the year bull trout, and therefore population (density) estimates for this age class must be viewed with caution. Electrofishing gear worked well for juvenile bull tout, as they seemed to remain within the habitat site being Shocked, while adult bull trout may have evacuated the site prior to block net placement. With this in mind, we believe that the population (density) estimates for juvenile age classes (1 + , 2 + , and 3 +) are most accurate.

The density (#/100m^2) of juvenile bull trout was highest in Mill Creek, followed by Wolf' Fork, Tucannon River, and Asodn Creek. This relationship was expected due to no harvest of bull trout in Mill Creek and difficult fisherman access into the Wdf Fork, while access into the Tucannon River is improved. The Asotin Creek bull trout population was inventoried in 1990, which resulted in five bull trout captured; on8 juvenile and four adults. Asotin Creek was reinventoried in 1991 farther upstream than in 1990. One juvenile bull trout was captured in this 1991 survey.

Several factors may be contributing to the low bull trout population in Asotin Creek. As a result of the Habitat Use and Preference data (secion 3.4.), we found that YOY bull trout use sites containing high amounts of boulder substrate. As a result of the Habitat Measurement data (section 3.2.), we found that Asodn Creek has a low percent of boulders as compared to gravel and cobble substrate. The lack of critical nursery habitat (hiding intrices) may be leading to poor survival for YOY bull trout in Asotin Creek. Pratt (1984) reported that first year bull trout spend more time under cover when larger cutthroat trout are present in tributaries Of the Flathead River basin. She also reports that instream cover which creates pockets of slow velocity within 0.2 m from the stream bottom may increase the amount of bull trout rearing habitat. She recommends that for bull trout management, boulders should be stacked on top of each other, creating spaces between the rocks similiar to large unembedded substrate cover for bull trout; Her findings, as well as those found in this study, suggest that YOY bull trout habitat is limited in Asotin Creek, and may be responsible for the small population in this stream.

YOY bull trout densities were compared between the three study streams where they were found, to other published data (See table 4.3.1.).

Table 4.3.1. Comparisons of bull trout densities (YOY + Junenile) in southeast Washington streams to other Pacific Northwest streams, as-wall as the method used for enumeration. Values for the current study were taken from Table 3.4.2. in the Results section of this report.

RIVER	DENSITY (#/100M2)	# PER RIVER KILOMETER	REFERENCE	ENUMERATION METHOD
Long Cr., Oregon		2.7 - 4.6	Bond and Long (1979)	Electroshock
Alberta streams		13	Carl (1985)	Electroshock
Flathead R. tribs.	0.7 - 37.5 (Juv.)	NA	Pratt (1984)	Day snorkeling
Metolius R., Oregon	20.6 (all ages)	NA	Goetz (1991)	Electroshock
Metolius R., Oregon	1.8 (1 + & older)	NA	Goetz (1991)	Day snorkeling
Metolius R., Oregon	9.8 (1 + & older)	NA	Goetz (1991)	Day/night snorkel
Flathead R. tribs	5.4 (all ages)	NA	Shepard et al.(1984)	Electroshock
MacKenzie & Hill, B.C.	14.0 (all ages)	NA	Shepard et al. (1984)	Electroshock
Profile Cr., Idaho	6 (1 + only)	600	IDFG (1991)	Day/night snorkel
Mill Cr., Wa.	5.2 (Juvenile)	236	Current study	Electroshock
Wolf Fork, Wa.	1.9 (Juvenile)	73	Current study	Electroshock
Tucannon R., Wa.	4.9 (Juvenile)	272	Current study	Electroshock
Mill Cr., Wa.	13.4 YOY & Juv	645	Current study	Electroshock
Wolf Fork, Wa.	9.2 YOY & Juv.	353	Current study	Electroshock
Tucannon R., Wa.	5.4 YOY & Juv.	299	Current study	Electroshock

in Mill Creek, mean YOY bull trout density was 5.2, Wolf Fork was 1.9, Tucannon River was 4.9, and Asotin Creek was 0 per 100m². The highest density was 23.8 YOY bull trout per 100m² in Mill Creek. These values are lower than those reported by- both Pratt (1984) and IDFG (1991).

Skeesick (1989) noted that age 1 + bull trout represent 20% of the catch in tributaries of Flathead Lake, Montana. if this value is accurate for populations in southeast Washington streams, mean age 1 + bull trout densities could be as high as 30 per 100m². This value was obtained by multiplying the highest age 1 + bull trout densitiy by 5. Therefore bull trout densities may be very similiar in Mill Creek and Profile Creek, Idaho.

it is difficult to make comparisons of our data to that reported in the literature for several reasons:

1) Sampling techniques vary; day time snorkeling, night time snorkeling, traps, and eletrofishing are the methods most commonly reported,'
2) Bond and Long (1979) and Carl (1985) reported the number of bull trout per stream length, as opposed to density,
3) IDFG (1991) used sites composed of many habitat types, while my sites were each composed of a unique habitat type, and
4) IDFG (1991) report density for only one age clads.

Juvenile steelhead trout densities were much higher in Asotin Creek as compared to the other study streams, which may ba attributed to several factors. Asotin Creek is a short river (45 Km), that drains directly into the Snake River and supports run of summer steelhead trout. There is no harvest of these fish in this stream, and as a result the populadon may be high in this stream. Steelhead trout Spawning ground surveys 818 conducted annually on this river by WDW to determine the number of redds, and the number of adults (Schuck 1 991). In 1991, inclement weather precluded surveys in most of this stream, and those surveys that were conducted occured when 'the water was turbid, and therefore absolute counts we18 difficult. With no knowledge Of the number Of adult steelhead in this stream, interstream comparisons cannot be made to determine why the population was so much higher in this stream. Several factors may be leading to. the high values:

1) We surveyed in the highest steelhead production area of this stream, and not in the other streams:
2) High spawner escapement occured in this stream, as compared to the other streams;
3) High egg to fry survival occurs in this stream;
4) The density of other salmonids in this stream are extremely low, therefore'. only' intraspecific competition exist; or,
5) The south fork of Asotin Creek was blocked to escapement in 1991 by beaver dams, which forced adult steelhead trout into the north fork Asodn Creek, resulting in an increased density of 0 age steelhead trout.

4.4 RELATIVE ABUNDANCE

Relative abundance data was collected to determine bull trout abundance in relation to other species in each stream. We speculated that bull trout would be present in areas of high sculpin and juvenile steelhead trout densities, as it is documented that bull trout predate on these species. Of

25 bull trout. examined in the McKenzie River, Oregon, none were found to have eaten salmonids. In Oregon's Imnaha River, 8 of 9 bull trout (avg. length 350 mm) that were studied had consumed only salmon fingerlings (Oregon Fish Commission 1959):

Bull trout density, as determined during relative abundance surveys, were extremely low in each of the study streams, which may be attributed to:

1) No block nets were used in relative abundance studies,
2) Only one person netted stunned fish,
3) low. conductivity resulted in low electrofisher efficiency;
4) Local disturbance, which caused fish to emigrate the site, and
5) We selected only juvenile and adult bull trout, ignoring YOY bull trout.

Steelhead/rainbow trout density, as determined during relative abundance surveys, were also low, which may be attributed to the above reasons. Scuipins, however, were readily captured and density values are more accurate for this organism than bull trout or steelhead/rainbow trout.

4.5. HABITAT UTILIZATION AND PREFERENCE DATA

Results showed that *YOY* bull trout use (density), increased with increases of boulder substrate and overhead cover. This result is supported by Pratt (1984), who states that the fish are occupying the low stream velocity pocket water formed by boulders. Shepard et al. (1984), reports that *YOY* bull trout have very specific habitat requirements, noting that they are bottom-dwellers, occupying positions above, on, or below the stream bottom. Bull trout are found in shallow, slow, backwater eddies often associated with logging residue (Shepard et al. *1984).*

Young-of-the-year bull trout used riffle and cascade habitat more than pool 01 run in all three streams where they were found. We found that juvenile bull trout density increases with increased of cobble substrate and overhead cover. Armstrong and Elliott (1972), state that riffles and glides were used by juvenile bull trout in British Columbia streams. These habitat types contain high percentages of cobble substrate. Griffith (1979) and Shepard (1984), both stat8 that substrate types associated with juvenile bull trout are primarily cobble and gravel. We found that juvenile bull trout used pool, riffle, run, and riffle habitat almost equally, in all three streams where they were found.

Table 4.5.1. was created to show the relationship between several measured habitat characteristics and fish utilization. This table is not an

actual habitat utilization table; the table shows trend information only. Utilization was determined by dividing the number of fish collected at each measured habitat characteristic, by the total number of fish collected for each species and age group reported. Plus (+) signs indicate that use increased with increases in the measured habitat characteristic. Negative (-) signs indicate that use decreased with increases in the measured habitat characteristic, while zero (0) indicates that no relationships between use and the amount of the habitat characteristic were found.

Table 4.5.2. shows the cummulative figures for all three study streams that bull trout were found in. As stated earlier, young-of-the-year bull trout were difficult, to capture by electrofishing, and as a result, actual values may be higher than reported for those habitat characterisitics that afford the fish hiding cover; namely boulder, woody debris, and turbulence. We would have, more than likely, captured any YOY bull trout present, reguardless of the amount of gravel or overhead cover, as these offer them no hiding cover.

Table 4.5.1. Relationship between habitat characteristics and the corresponding fish utilization ("-" = negative relationship, "0" = no relationship, and "+" = positive relationship).

MILL CREEK	BULL TROUT Y-O-Y	BULL TROUT JUVENILE	RAINBOW TROUT Y-O-Y	RAINBOW TROUT JUVENILE
Gravel	0	0	0	0
Cobble	+	+	+	-
Boulder	+	0	-	0
Overhead Cover	0	0	0	+
Woody Debris	0	+	+	0
Undercut Bank	-	0	-	-
Turbulence	0	0	0	-

WOLF FORK	BULL TROUT Y-O-Y	BULL TROUT JUVENILE	STEELHEAD Y-O-Y	STEELHEAD JUVENILE
Gravel	+	0	0	+
Cobble	0	-	+	-
Boulder	+	0	0	0
Overhead Cover	+	0	-	0
Woody Debris	0	0	+	+
Undercut Bank	+	0	0	0
Turbulence	0	-	0	-

TUCANNON	BULL TROUT Y-O-Y	BULL TROUT JUVENILE	STEELHEAD Y-O-Y	STEELHEAD JUVENILE
Gravel	0	0	+	0
Cobble	0	0	0	0
Boulder	+	-	0	-
Overhead Cover	+	+	0	+
Woody Debris	+	+	+	0
Undercut Bank	0	+	0	+
Turbulence	0	+	0	-

Table 4.5.2. Cummulativo **figures** for all **three study streams** that **bull** trout **were found in.**

CUMMULATIVE	BULL TROUT Y-O-Y	BULL TROUT JUVENILE	STHD\RAINBOW Y-O-Y	STHD\RAINBOW JUVENILE
Gravel	+ +	0	+	+
Cobble	0	0	+ +	–
Boulder	+ + +	-	-	-
Overhead Cover	+ +	+	-	+ +
Woody Debris	+	+ +	+ + +	+
Undercut Bank	0	+	-	0
Turbulence	+	–	0	–

For interspecies competition to occur, the speciesmust overlap in their geographic range. Our data shows that minimal habitat utilization overlap occurs between bull trout and steelhead/rainbow trout in the study streams. Juvenile bull trout and spring chinook salmon only minimally overlap in the Tucannon River, and therefore do not compete for rearing habitat.

If the category, overhead cover and the age class YOY for steelhead/rainbow trout is ignored, there is only one habitat characterisitc that shows fish utilization increases with habitat increase. That'habiit characteristic is gravel and it is used increasingly by juvenile steelhead trout and YOY bull trout in the Wolf Fork. Co-species habitat utilization did not increase for any other habitat characteristic measured.

Table 4.5.2. shows fish utilization increases for several of the habitat characteristics measured, however they were. not in the same stream. Therefore competition can not be occurring. This table was created to increase the magnitude of the trends seen in each of the streams individually, and should only be used to suggest the "preferred habitat characteristics" of each age class of bull trout and steelhead/rainbow trout.

Young of the year and juvenile steelhead trout utilized pool and run habitat the highest in all four streams, as is reported for other streams for this species; Viola (1990) noted an increase in density and biomass of older aged steelhead trout/rainbow trout with Increases in pool habitat. Hillman (1989) noted that in day time during summer, steelhead lived in shallow, slow water.

This data shows that the two species overlap in their general habitat preference, however microhabitat utilization (substrate, instream cover, 'and overhead cover) 'differed. It appears that the two species have similiar habitat preferences but-that they partition the resource so that each uses a narrow portion of the unit.

Due to their depressed numbers and federal protection, few spring chinook salmon were collected in our 1991 sampling. Therefore, habitat utilization and preferences could not be established; There is, however, considerable information concerning the habits of juvenile spring chinook salmon in Pacific northwest rivers and streams. Hartman (1965) reported that coho salmon (*O. kisutch*) in the presence of steelhead trout, preferred pools containing fine sediment and lacking complex instream cover. He found that stream temperatures utilized were 8^{o} C to 17^{o} C. House (1986) 'reports, that salmon (sp.) in Tobe Creek, Oregon, preferred pools with fine sediment but were also found using open glide-run habitat. House (1986) also reported that this creek could be improved by adding some structure to act as scouring agents to produce more pools.

In the Tucannon River, the juvenile spring chinook salmon that. were' collected; were collected in run (the number of fish collected, n = 2), cascade (n = 3), plunge pool (n = 6), and scour pool (n = 42). In Asotin Creek, the juvenile spring chinook salmon that were collected, were collected in run (n = 1), and pool (n = 4). Although we have-a very small sample, I speculate that spring chinook salmon prefer pool habitat in these two streams,

These data suggest that spring chinook salmon differ from juvenile bull trout in their habitat preferences. Juvenile spring chinook salmon prefer 'open" slow water that has small substrate and lacks complex hidlng cover. Juvenile bull trout use riffle and cascade habitat more than pool or run, and their densities increase with increases of woody debris and boulder substrate.

4.6. FOOD AVAILABILITY AND FEEDING HABITS

Benthic macroinvertebrate density calculations were based on three, 1 /10 m^2 samples collected at one transect in each stream. This is obviously weak sampling, however, our intention was not to quantify total invertebrate production, but to determine the relative proportions of each taxa of, invertebrates present in each stream, and to assess stream similarities or differences; These proportions were then compared to that found in the stomachs of bull trout and steelhead/rainbow trout collected near the invertebrate sampling transect in each stream. Etectivity values, which indicate how the selected diet differs from a diet selected at random, were then calculated. This information was then used to describe the preferred diet of each species in each stream.

Benthic macroinvertebrate densities were similiar between streams, as were the electivity values. Most electivity values were near zero, indicating no strong preference for any taxa of invertebrate. Scott and Crossman (1973), report that juvenile bull trout consumed adult and immature insects, snails, and leeches. Salmon eggs are reportd to be important in the fall. Shepard (1984), report that at a length of 110 mm to 140 mm, the bull trout become increasingly piscivorous. However, Jeppson and Platts (1959), noted that in northern Idaho lakes, bull trout from 100 mm to 300 mm ate only insects. We found similiar results; nine of 60 juvenile bull trout (100 < x < 250 mm) collected in July and A&gust, 1991, had Cottidae (sp.) in the stomach, while in 1990 one out of 1 1 adult bull trout (> 250mm) had two steelhead fry, and one out of 11 had a cottidae (sp.) in it's stomach. It must be noted that nine of the 11 adult bull trout stomachs collected in 1990 were empty.

Fraley and Sheppard (1988), 'report that adults on their upstream migrations probably feed little if- at all. This may explain the high number of empty stomachs recovered from adult bull trout in July and August.

In Sun Creek (Klamath River drainage, Oregon), Wallis (1948), found that adult, stream resident (fluvial) bull trout, ate, in decreasing order of abundance, Diptera, Trichoptera, Ephemeroptera, and Plecoptera. We found that juvenile bull trout ate, in decreasing order of abundance, Ephemeroptera, Diptera, and Plecoptera.

Fluvial populations show an increase use of fish as prey items. Of 25 fish examined in the McKenzie River, Oregon, none were found to have eaten salmonids. On Oregon's Imnaha River, eight of nine bull trout (avg. length 350 mm), that were studied had consumed only salmon fingerlings (Oregon Fish Commission 1959).

Stomach collection, at times other than during their upstream migration to spawn, may result in more salmonids in the stomach. Fish were collected during July and August for this study. If sampling had occured in December through June more salmonids may have been present in the gut.

It is interesting to note that bull trout consume a number of exotic items, including squirrels, ducklings, snakes, mice, frogs, and even dipnets (Skeesick 1989).

Bull trout and steelhead trout consumed similiar taxa of invertebrates in each, of the study streams as indicated by the diet overlap values. However they elected these taxons in, proportion to their availability, and therefore appear to be opportunistic in their feeding habits. Invertebrate production is high in these southeast Washington streams. Bugert (1989), estimated that in the Tucannon River at the current (1989) fish population, it would take 89 days to eliminate the most limited invertebrate taxon, if there was no further invertebrate production.

For competition to -occur the resource. must be limited. Food is no? limiting in these streams as indicated by Bugert (1989). The electivity indices and invertebrate production data collected in this study also showed that food is not limiting in these streams. As a result of our findings there is. minimal interspecies competition for food between juvenile bull trout, juvenile steelhead trout, and juvenile spring chinook salmon in the study reach of the study streams.

4.7. BULL TROUT MOVEMENT AND MIGRATION

We were able to collect only limited movement and migration information about bull trout in the Tucannon River. Those fish that were tagged, and later captured by anglers (n = 4), moved upstream an average of 1 6 km in 25 days during the months of June and July. This coincides with an increase in stream temperature and a decrease in river discharge. McPhail and Murray (1979), found peak upstream movement to coincide with maximum water temperature (1 O-1 2 C°) and minimum flows.

July represents the beginning of adult bull trout's upstream' journey to spawn; bull' trout spawning began on September 6, 1991 in'the Tucannon River, 30 km up&ream of the tagging location. If those fish that were captured by anglers had continued to move upstream at a rate of 15 km per 25 days, they would have ascended the stream to their spawning area in the middle of August, just 15 days before the initiation of spawning.

McPhail and Murray (1979), and Shepard et al. (1984), report that adult bull trout feed little or not at all im their upstream mlgratlon. We found similiar information; nine of 1 1 adult bull trout stomachs were empty in 'July, 1990, and four of five adult bull trout stomachs were empty in 'August, 1991.

We speculate that adult bull trout (> 250 mm), move downstream some distance below Rk 62 (fish hatchery) in the Tucannon River in November and December, and overwinter. They begin to move back upstream in April and May; past the hatchery trap in June, and arrive at their spawning area in middle to late August. Shepard et al; (1984) report that in fluvial and adfluvial bull trout populations, adults undergo spawning migrations of up to 225 Km. Adults from fluvial populations are found in rivers and larger streams. Smaller tributaries act as breeding grounds and rearing areas for juveniles. This same type of life history pattern Is observed In the Tucannnon River, Washington.

We are certain that age 0 + through age 1 + or 2 + bull trout do not leave their nursery areas in late fall, like the older fish do. The rationale is that very few have been observed by snorkeling or trapping in downstream reaches of the Tucannon River, while adult bull trout are both seen and trapped (Bugert, WDF personal communication, 1991). WDF (Bugert 1988-901, conducts winter snorkeling surveys on the Tucannon River from Rk 77.5 (Panjab Creek) to Rk 60 (below the Tucannon River fish hatchery). Bugert (personal communication, 1991), reported that no juvenile bull trout (< 200 mm), have been observed in this reach of the river in December or

January for the years 1988 through 1991 . Yet in December, we collected juvenile bull trout in their nursery area at Rk 84.3 (Sheep Creek) by electrofishing, indicating further, that- juvenile bull trout remain in their nursery area overwinter.

Fraley and Shepard (1988) report that adfluvial adults mature in lakes and reservoirs before undergoing spawning migrations. Martin (1985) reports that adults start their upstream movement from Flathead Lake during April and May and arrive in tributary streams in July and August. This same pattern, was observed in the Tucannon River. Our use of fluvial to describe the life history pattern of bull trout may be erroneous because the Tucannon River drains directly into the Snake River above Lower Monumental Dam. There are no obstructions to migration in this river, so bull trout could emigrate to the Snake River, overwinter, and in April and May return *back* upstream. If this is the case, bull trout in this river would be called adfluvial.

There are two reasons to suggest that bull trout are adfluvial in southeast Washington streams; 1)bull trout have been observed ascending the adult fish ladder at Lower Monumental Dam on the Snake River on three different occasions (Kleist, WDF personal communication, 1991), and 2) juvenile bull trout have been captured in WDF smolt trap on the Tucannon River (RK 15) (Mendell, WDF personal communication, 1991). We believe,. however that if bull trout in this region are adfluvial, the proportion of the population that exhibits this life history pattern is low. This belief is due to; 1) no reports exist of bull trout being captured in the Snake River or lower Tucannon River during the winter steelhead season on these rivers, and 2) very few (3 I believe) bull trout have been observed ascending the adult f&h ladders on the Snake River dams. The possibility of an adfluvial life history pattern needs further. investigation in this region..

4.8. AGE, GROWTH, AND CONDITION

The ages of bull, trout from each of the streams surveyed were similiar for each life history stage. That is, in the summer of their third year of growth (age 2+, II), they were on the average, 180 mm fork length, and in the summer of their fourth year of growth (age 3+, III) they were on the average, 215 mm fork length. Table 4.8.1. reports the growth (mm) of bull trout in the three study streams of southeast Washington that bull trout were captured in.

The ages in Table 4.8.2. are reported for fish length in July and August, 1990 and 1991. The values in table 4.8.1. are for length at annulus formation, therefore my age 0+ (I) fish will be longer than reported when they actually form their first annulus. The same holds true for all reported ages. Given that the fish are half-way through the growing season, a mean value between two of the length at age values reported in table 4.8.2. would be a better comparison to that in table 4.8.1.

Table 4.8.1. Bull trout growth (mm) in various drainages. . Length is reported for total length of the fish at annulus formation.

RIVER	I	II	III	IV	V	VI	VII	SOURCE
Middle Fk. Flathead River	52	100	165	297	399	488	567	Fraley & Shepard (1988)
North Fk. Flathead River	73	117	165	301	440	538	574	Fraley & Shepard (1988)
Upper Willamette River	93	142	165			264	284	*Ore. Game Comm
Roberts Creek,John Day R	67	111	132					*Ore. Game Comm.
Metolius River tributaries	57	92	141					Ratliff (1987)
Metolius River tributaries	70	107						Ratliff 91989)
MEAN	68	112	154	299	420	430	475	

* In Skeesick (1989).

Table 4.8.2. Bull trout growth (mm) in the three study streams. Sampling was in July and August, 1991, therefore age is indicated by a " + ". The average value between summer length for two age classes is reported as the expected length at annulus formation, indicated by roman numerals.

RIVER	0+	I	1+	II	2+	III	3+	IV	4+	V	5+	VI
Mill Creek	55	83	110	135	160	198	235	304	373			
Wolf Fork	55	80	105	130	155	163	170	260	350	410	470	
Tucannon R.	45	68	90	118	145	170	195	247	299			
MEAN		77		128		177		270		410		

It is reported that bull trout growth is constant after their third annulus is formed (Skeesick 1989). We were unable to confirm this in southeast Washington streams; average growth from annulus I to annulus II was 50 mm; II to III average growth was 45 mm, III to IV average growth was 90 mm, IV to V average growth was 1 20 mm. Bull trout from the study streams did show an increase in growth after age 3 + (III). This has been identified in other streams and is attributed to bull trout switching from a diet composed of insects to a diet composed of fish (Skeesick 1989). However the growth increase after age 3 + in southeast Washington streams was not as marked as other Pacific Northwest drainages reported in table 4.7.1. This may be due to:

1) Low sample size in this study;
2) Low density of naturally produced juvenile steelhead or salmon; or;
3) Fluvial life history.

The age of bull trout in southeast Washington streams reported in Table 4.7.2. were determined by constructing a length-frequency histogram for ages 0+ through 2+, which was confirmed by otolith analysis. Otoliths were used exclusively for ages beyond 2 + . Many researchers have found aging of the bull trout to be problematic (Hanzel 1986; Fraley et al. 1981; and Brown 1984).

Fraley et al. (1 981) listed 100% agreement between otolith and scale readings for age 0 to 3. Fraley believed that aging of scales is the best, method, while otoliths should be used to verify scale readings. However,' Brown (1984) found that a lower then actual age may been given to older bull trout examined.

Otoliths were used to determine the age of older bull trout for several reasons. Caakso and Cope (1956) found 3 forms of cutthroat trout in Yellowstone Park: trout 'that did not form an annuli in their first year, trout that had some scales with annuli and some without, and trout that had fully formed annuli on their scales. They concluded that the abnormal scale formations (and lack of scales) were related to the time of emergence of the fry in the summer, and whether the fry had a change to grow before the growing season was terminated (they reoprt that fish that reached a size of 41-44 mm usually had sclae plateletes formed), Peven (1990) reported that steelhead that hatch in the headwater streams 'of north central Washington, are exposed to the extremely cold temperatures that could affect the formation of an annulus in their first year of life.

We believe the probability is high that annuli are not formed on the scales Of some bull trout in southeast Washington streams. O'Gorman et al (1987) found that annuli were not laid down on the scales of alewives in the Great Lakes, and that otoliths were, a more reliable means of aging. We are in agreement with these researchers; upon inspection of several scales from various age (length) bull trout, It was concluded 'in this study that annular growth rings were not discernable or not present, and therefore otoliths were. used for age analysis.

We used three experienced persons in otolith analysis and three indices of age reproducibility to be certain that the age reported was. the most accurate age. A comparison of age 1 + , 2 + , and 3+ to a length-frequency histogram created from fish captured during population inventories of each stream was also made, We are certain that through age 4+ (IV) the ages reported are indicative of the number of annuli, and therefore winters the fish has lived. Beyond age 4+, the sample size becomes too small to allow for confidence in my results, however independant readings result&d in an average percent error of 0.03 for age 5 + (n = 12), 0.08 for age 6+ (n = 3), and 0.0 for age 7+ (n = 3).

Length-weight data (condition) collected for bull trout in each of the study streams was similiar for YOY and juvenile bull 'trout. Habitat-specific condition factors were assessed to see if bull trout were in better condition in specific habitat types. Bull trout showed higher condition in riffle habitat then pool, cascade, or run habitat, but because of small sample size and multiple age groups included in the analysis, this information should be used with caution;

The longest (fork length) bull trout collected was 655 mm (26"), however, we observed several bull trout constructing redds in Mill Creek that were in excess of this length. Four bull trout greater than 600 mm (24") were trapped in the Tucannon River anadromous fish trap located at Rk 62, in 1991. We observed only three bull trout greater than 600 mm (24") constructing redds in the Wolf Fork in 1990 and 1991.

From these observations and data, bull trout in these streams probably do not grow greater than 762 mm (30") fork length, however a local resident reported that he caught a 36" (914 mm) male bull trout in the Wolf Fork in 1984 (a photograph confirmed the fish). Tucannon River fish hatchery manager Bill Hubbard, reported a bull trout in excess of 30" (760 mm) holding in a hatchery effluent stream (Hubbard 1991). This report was latter confirmed when the fish was removed from the effluent stream. This fish may be taking advantage of an artificilly high supply of food and thermally stable water source, and therefore is considered an anomoly.

4.9. FECUNDITY, SPAWNING GROUND. SURVEYS, AND REDD CHARACTERIZATION

Bull trout fecundity increased exponentially with fish length, as reported for many salmonid species. Figure 3. 13.1 shows the relationship between fork length and fecundity for seven bull trout collected from the study streams in southeast Washington. Fecundity ranged from 490 for a 270 mm bull trout to 3,350 for a 620 mm bull trout. McPhail and Murphy (1979) report that bull trout in the MacKenzie Creek, British Columbia, had a mean fecundity of 1,442 for 470 mm bull trout. In the Clark Fork River, Idaho, fecundity for bull trout, mean length of 544 mm-was 3,821 with a range of 2,136 to

6,753 (Heimer 1965). In the Flathead River, Montana, fecundity for bull trout, mean length of 611 mm was 5,482.

Bull trout spawning activities, on the average, began on 8-September-1990 at an average water temperature of 7 °C (range of 5 °C to 10 °C), and ended on &November-l 990. The first redd constructed in each stream was one of the farthest upstream redds constructed for the season. A trend of larger fish ascending farther upstream to construct a redd in each stream was observed. There was usually an obstruction that prohibited larger fish from farther ascent, that smaller fish somehow ascended, to construct redds upstream even farther. The obstruction was always an accumulation of branches, twigs, bark, and other allocthonous matterials built up against a log, in effect cresting a dam that water permeated through but did not plunge over. These smaller fish, (250 mm to 350 mm) found passage through the obstruction and constructed redds upstream until the fish encountered one of the following obstructions:

1) waterfall,
2) shallow riffle (< 5 cm deep),
3) impervious organic dam (as described above), or
4) no more pockets of spawning gravel.

Fraley and Shepard (1988) reported that redd construction is usually complete&by one male and one female but sometime8 more than two fish. Ratliff (1987) noted that redd superimposition occurs in tributaries to the Metolius River, Oregon. Redd overlap was observed in several instances, although there appeared to be ample cobble substrate present in ideal habitat with hiding cover. It has been reported that redd superimposition may be due to limited spawning habitat, or that site specific characteristics required by bull trout are quite specific (Skeesick 1989).

Shepard (1985) lists the physical habitat-factors that influence bull trout redd placement: high order stream, streambed with a low % of boulders and greater amounts of gravel and rubble, low channel gradients, areas of overhanging bank cover, maximum stream temperatures < 18 Co, and areas of ground water recharge. All redds observed were constructed in first order streams, contradictory to that reported by Shepard (1985). All redds, as reported by Shepard (1985), were located in low gradient areas of each stream. Redd construction was usually close (< 1 m) to undercut banks and/or overhanging vegetation. Twenty-two of 28 measured redds were constructed in run habitat, the remaining five were constructed in the tail of a pool.

It is difficult to determine if redds were placed in areas of ground water recharge, however visual inspection of the immediate area around the redd may present some dues. Several bull trout redds were adjacent to, or immediately downstream, from springs or rock walls that were wet from seeping water. These would indicate ground water recharge.

A comparison of the physical characteristics of bull trout redds in each of the study streams to other streams in the northwest (Shepard 1984 *in* Skeesick 1989) is shown in table 4.9.1.

Table 4.9.1. Characteristics of bull trout redds in the northwest compared to those that were characterized in southeast Washington streams, 1990 and 1991.

DRAINAGE	MEAN DEPTH OVER REDD (m)	MEAN VELO. OVER REDD (m/sec)	MEAN DISTURBED AREA (m^2)	COBBLE AND LARGER (>50mm)	LARGE GRAVEL	SMALL GRAVEL	SAND	EGG DEPOSITION DEPTH (m)
Flathead River, Mt.	0.28	0.29	2.30	18	30	39	13	0.10- 0.20
Clearwater R., Alberta	0.24	0.62	0.69	5	12	72	10	0.03-0.18
MacKenzie Cr., B.C.	NA	0.60	0.80		31	61	8	0.10 -0.18
Wigwam R. and Ram Cr, B.C.	0.34	0.43	1.47	20	50		30	0.17 - 0.25
Kooteney Lake, Meadow Cr. and John Cr, B.C.	0.77	0.33	0.73	29	59		12	0.10 - 0.20
Clark Fork, River, Idaho	NA	NA	NA	38	20	42		NA
Washington Streams & Rivers	1.05	1.71	3.59	10	60	30		NA
Hood Bar Cr., Alaska	0.4	0.75	0.60	10	28	32	30	0.15
Mill Creek, Washington	0.29/.16*	NA	1.35	14	56	24	6	NA
Wolf Fork, Washington	039/.18*	0.33	1.01	13	43	43	3	NA
Tucannon River, Washington	0.21/.10*	0.26	1.88	9	61	29	2	Na

- First number represent the water depth in the bowl or pit, the second number refers to the water depth over the tail or mound.

The minimum length of any observed spawning bull trout was 250 mm- (10"), but the mean length was 480 mm (19") with the maximum length in excess of 655 mm (26"). There were usually two fish observed on a redd at any time, but another bull trout was commonly- near by. This third fish was usually smaller than those seen on the redd and if it entered onto the redd, it was immediately displaced by one of the larger fish. Detailed account8 of the behavior of bull trout and Dolly Varden have been given by several researchers (McPhail and Murray 1979; Oliver 1979). Scott and Crossman (1973) reported that dominant males show aggression towards subbordinates end defend localized ores, which is what was observed occurring on many redds.

4.10. TEMPERATURE AND STREAM FLOW DATA

As reported in the methods and results sections, continuous reading thermographs were deployed into each river near the speculated downstream range of bull trout. A chart was presented in the results section of this report showing the thermal regime for each stream, and it appears that the Tucannon River is the warmest of the four study streams. The thermograph that was located in the Tucannon River was maintained by WDF, and therfore was positioned in a location that met their objectives As a result, the thermograph was about 6 Km below the downstream range of bull trout in this stream. That distance seems negligable, however land use changes drastically over those 5 kilometes as compared to above the 5 Km. Easy vehicular access and maintained camping sites are the primary changes. As a result of these activities; the riparian canopy has been slightly reduced, and therefore the stream temperature increases. We believe‘ that, had the thermograph been located upstream further, the four study streams would have been similiar with respect to. thermal regime. Asotin Creek would have been the highest temperature if this adjustment was made.

An inspection of the chart presented in the results section of this report would be misleading. The chart was created to simply describe the thermal pattern of each stream, not to describe temperature use or preferences of bull trout. It is of Interest to note that several juvenile bull trout were Captured or observed by WDF and WDW in their routine summer sampling duties on the Tucannon River 10 kilometers below the thermograph location, which would indicate that juvenile bull trout do use stream temperatures greater than 16 ^{o}C in the Tucannon River. However, these fish were seen infrequently below the thermograph location, as compared to our sampling sites located five to 15 kilometers above the thermograph.

The warmest stream temperature where YOY bull trout were captured was 13 ^{o}C in the Tucannon River. The warmest stream temperature where juvenile bull trout were captured was 16 ^{o}C , again in. the Tucannon River. Juvenile and YQY steelhead trout were captured at every site that bull trout were captured in. As 8 result this data shows no difference in stream temperature utilization between these two species. However, Spring chinook salmon were only found in the lowest sites in both the Tucsnnon River and Asotin Creek. ‘Stream temperatures were 19^{o} C to 20^{o} C in these two streams at the lowest site, respectively. It appears that stream temperature seperates bull trout and spring chinook salmon in streams in southeast Washington. It may be attributed to a difference in preferences of the two species. Of. it may be that redd location, and subsequent YOY location, determines the location of each species, or both.

STREAM FLOW

It is difficult to make stream discharge comparisons, 88 there are no stream flow gauges located in the sampling reach of the streams. During our habitat measurement activities, we recorded stream flow et three of the six Segments in each stream.

Stream flow, in the study reach of each stream is presented in section 3.16, and shows that the Tucannon was largest in terms of flow, followed by Asotin Creek, Mill Creek, and the Wolf Fork. This data is misleading, as the Wolf Fork was surveyed on June 25 and 26, while the Tucannon River was surveyed on June 27 and July 1. Asotin Creek was surveyed on July 2 and 3, while Mill Creek was surveyed on July 1 1 and 16. The reason this information is, presented is that stream discharge we8 higher in June 1991, than normal, and 8s a- result those streams that were surveyed in June or early July are higher than base summer flow. Table 3.16.5 is presented to , allow for 'better comparisons of stream flow; Mill Creek in the area of high YOY bull trout density was 22.3 c.f.s. (7/11/91), Wolf Fork in the ares of high WOY bull trout density was 8.32 c.f.s. (7/16/91), the Tucannon River in the ares of high YOY bull trout density was 11.7 c.f.s. (7/24/91).

Stream flow at the highest redd in each stream was estimated to be 4.5 c.f.s. in Mill Creek, 2.0 c.f.s. in the Wolf Fork, and 2.6 c.f.s. in the Tucannbn River..

The data collected during the first of this species interaction study shows. that interspecies competition between juvenile -bull trout, steelhead trout, and spring chinook salmon in southeast Washington streams is not occuring at current population levels. However, competition between juvenile bull trout and juvenile steelhead trout may be occuring for rearing habitat, but only minima4 habitat preference shifts were identified. between populations in allopatry and sympatry.

5.0 FUTURE RESEARCH NEEDS AND RECOMMENDATIONS

There are several methods currently used to determine bull trout population density in small streams. These methods include: snorkeling, both day and night, electroshocking, and trapping. Problems have been identified and described with each of these methods.

Visually observing YOY and I + age bull' trout is difficult in small streams because of shallow water, dense and complex hiding cover,' poor visibility due to a dense riparian canopy associated with small streams, and fish entering the substrate. Shepard (1984) reports that juvenile bull trout can be found on or below the substrate.

Night-time snorkeling estimates wore reported to be 2.5 times greater than day snorkeling in the Metolius River, Oregon (Goetz 1990). This figure should be used with caution, however, because the mean6 were reported from a large number of day time counts (210 habitat units) and only 42 night time units, and not from paired sites (IDFG 1991). This data Is substantiated, however by Goetz (1990) reporting higher upper ranges of night time counts for individual streams.

In Profile Creek, Idaho, IDFG (1991) reoprted minimal diferences between day and night snorkel counts in 5 of 6 sites. IDFG (1991), states that woody debris was sparse in Proflie Creek, which may be the reason for such consistent day and night counts, while A was abundant in the Metolius River sample sites. Daytime counts on the Metolius River may be less effective 'if bull trout are selecting for woody debris cover during the day.

Minnow trap6 were used to estimate Dolly Varden populations by Bloom (1976). Hi6 results showed that these traps do not capture juveniles smaller than 41 mm or larger than 130 mm. Minnow trap6 have been used to capture redside shiners in the Tucannon River and found that the small fish (45 mm - 80 mm) in the trap were easy prey for larger fish (140 mm - 160 mm) that entered the trap. . A6 a result, minnow traps were &continued in the Tucannon River._ Lestelle (1978) reported that fingerling trapping has been successful in Oregon or Washington for fish as small 8s 75 mm.

Electrofishing was found to be effective for determining juvenile bull trout densities in riffle, run, and cascade habitat in each of the study streams. It seemed to be less effective in larger, deep pools, as the capture coefficient of variation increased considerably in this habitat type. Shepard et al. (1982), found this same trend, reporting that habitat type may play a role in comparability and effectiveness of snorkeling and electrofishing. Bull trout snorkel counts and electrofishing estimates were simiIiar for riffle and pocket water but varied widely for pool and run habitat (Shepard et al. 1982). IDFG (1991) concluded, and we concure, that if an absolute estimate of juvenile bull trout density is considered critical, electrofishing (using block nets) should be conducted whenever possible.

The diet of bull trout seems to vary considerably both within and between streams of the Pacific northwest. Boag (1987), reported that above a beaver dam in an Alberta stream, butt trout ate only insects, white immediately below the dam, in the presence of juvenile rainbow trout, bull trout ate predominately rainbow trout and their eggs. Bull trout are opportunistic and adaptive feeders. Skeesick (1989) reports the findings of many researchers, and should be reviewed prior to conducting a diet analysis of bull trout. To conclude; we 'believe that the bull trouts' diet. is a function of its environment; organisms that are present will be consumed. This is substantiated in the three study streams in southeast Washington that were studied; electivity values were all clustered near zero, indicating no preference for invertebrates in relation to their availability in the environment.

Furthermore,. any diet analysis in these streams, unless done on an extremely large number of fish, will provide no further information on this subject. However, if researchers wish to quantify the number of fish or eggs consumed, the use of emetics or iavage techniques may serve them welt. The results of the 1990 and 1991 diet study show that adult bull trout feed little, if at all on their upstream migration in June and July. The need arises, then, to sample these fish in other seasons. This would be necessary to determine their annual feeding habits and asses their impacts on juvenile salmonid species in these streams.

The macro-habitat and habitat 'characteristic preferences of YOY and juvenile butt trout were adequately described in this report, however the micro-habitat (focal point) of juvenile and adult bull trout were not described. We feet that summer micro-habitat utilization and preferences for juvenile bull trout have been well defined by several authors (Pratt 19984; Shepard 1984; Armstrong and Elliott 1972; McPhail and Murray 1979; Fraley and Graham 1981; Oliver 1979; and Ratiiff 1988). Limited information, however, is available on the winter habitat of YOY and juvenile butt b-out and summer and winter adult butt trout.

it was found that during the winter months, Dotty Varden juveniles hide in dense mats of debris, or they may swim upstream to areas of ground water seepage (Armstrong and Elliott 1972). The winter behavior of many salmonids is presently known, and we would suspect that butt trout behave very similiarly. As temperature decreases, metabolic activity decreases and most juvenile salmonids burrow under rock or rubble.

We were unable to quantify or sufficiently qualify the preferred habitat of adult bull trout in southeast Washington streams. Adultbull trout either evacuated the population inventory sites, or were not present in the site to beginwith. As a result, information on adult bull trout habitat preference is lacking;

In order to describe the habitat preferences of adult bull trout, it will be necessary to make visual observations of the fish; snorkeling is the recommended method.

Fish movement and migration in the Tucannon River was not adequately, described due to small sample size and data from only three recaptured fish. The movement and migration of bull trout is crucial information to describe. their relationship with returning spring chinook salmon into the Tucannon River, and spawning steelhead trout. Currently, the only known information on the Tucannon River is that bull trout move upstream, past Rk 82 in June, spawn in September and October, and return some distance downstream. Some descend the stream beyond the hatchery (Rk 62), but it is not. known if this is true for only a small portion of the population, or for a majority of the population.

Steelhead trout spawn from Rk 30 to Rk 90 (Schuck, 1990 personal communication). Several questions need addressed. Do bull trout interact with the fish in April and May where they spawn, and do buff trout ascend the stream in June and July to interact with the spring chinook salmon or because of stream temperature? These are important questions that must be addressed to fully understand the magnitude of species interactions in the Tucannon River.

The use of radio telemetery would be the recommended technique to describe bull trout movement and migration in the Tucannon River. This method would also allow for a description of habitat preference of these fish, as it would allow an observer to locate the fish quickly and observe its relationship to its physical environment.

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APPENDIX A.

MATHEMATICAL IDENTIFICATION OF BULL TROUT COLLECTED FROM EACH OF THE STUDY STREAMS, 1990 AND 1991.

MATHEMATICAL IDENTIFICATION OF BULL TROUT

Bull trout and Dolly Varden (*Salvelinus malma*) are the only species present in Washington State that belong to the Charr family. Until 1978 these two species were considered to be one species; Dolly Varden. After further examination by Cavender (1978) they were determined to be seperate species based on the examination of morphology, meristic counts, and bone structures. Haas (1988) developed a method using branchiostegal number, anal fin ray number, maxillary length, and standard length that separates Dolly Varden and bull trout completely. The advantage of this formula is that all four measurements can be made in the field without killing the fish. This is an important consideration as bull trout are fisted as a Category 2 species by the U.S. Fish and Wildlife Service and are being considered for possible addition to the List of Endangered and Threatened Wildlife under the Endangered Species Act of A 973.

As a result of Cavender (1978) and Haas's (1988) work, it was determined that Dolly Varden inhabit coastal areas of the Pacific Northwest and are usually anadromous 'while bull trout are found 'in interior areas and are not anadromous. The geographic range of bull trout and Doily Varden overlap in the Puget Sound area of Washington and along the British Columbia coast (Cavender 1978, Haas 1988).

Haas's (1988) unweighted linear discriminant function is:

$$f = [(0.63 \times b) + (0.18 \times a) + (37.31 \times m/s)] - 21.8$$

Where: f = linear discriminant function;
b = the total number of branchiostegals;
a = the number of anal fin rays; and
m/s = the maxillary length/standard length ratio.

All branchiostegals must be counted, the best method of counting these slender bones is to hold the fish by the lower jaw and opening the mouth to "flare" the gill covers. It is reported that the branchiostegal number alone will separate about 80% to 90% of the fish (Haas 1988).

All principal anal fin rays must be counted, however do not count the branches of a ray, only the primary ray itself.

The maxillary length should be measured from the tip of the snout to the posterior tip of the maxillary bone, All measurements were taken in a straight line, from point to point, rather than around the curve.

TABLE A.1. Meristic data collected from bull trout in Mill Creek in 1990 and 1991. Values were entered into Haas's (1988) Dolly Varden/bull trout differentiation formula.

Formula: [(0.63 x branchiostegal #) + (0.18 x anal fin ray #) + (37.31 x maxillary length/standard length ratio)] - 21.8

Meristic data collected from bull trout in Mill Creek, 1991.

DATE OF COLLECTION	BRANCHIO-STEGAL #	ANAL FIN RAY #	MAXILLARY LENGTH	STANDARD LENGTH	FUNCTION
25-Jul-91	25	9	20	135	1.097
25-Jul-91	25	9	19	138	6.707
25-Jul-91	28	9	21	155	2.515
25-Jul-91	24	9	28	202	0.112
25-Jul-91	26	9	32	231	1.368
25-Jul-91	24	9	19	149	-0.302
25-Jul-91	27	9	84	565	2.377
25-Jul-91	27	9	21	158	1.789
25-Jul-91	24	9	21	151	0.129
25-Jul-91	25	9	21	158	0.529
25-Jul-91	26	9	19	138	1.337
14-Aug-91	28	10	41	311	2.559
9-Aug-91	26	10	46	321	1.727
8-Aug-91	24	10	19	169	-0.685
8-Aug-91	26	10	25	181	1.533
8-Aug-91	26	10	26	195	1.355
8-Aug-91	26	10	19	145	1.269
8-Aug-91	26	10	20	158	1.103
6-Aug-91	26	10	19	145	1.269
6-Aug-91	26	10	26	183	1.681
6-Aug-91	26	10	29	212	1.484
6-Aug-91	25	9	27	169	1,531
6-Aug-91	26	10	25	194	1.188
6-Aug-91	28	10	28	205	1.476
6-Aug-91	25	9	25	185	0.612
8-Aug-91	26	10	20	151	1.322
8-Aug-91	27	9	24	192	1.494
29-Aug-91	26	10	30	218	1.514
29-Aug-91	28	10	28	192	3.081
29-Aug-91	29	10	28	199	3.520
29-Aug-91	27	10	23	205	1.196
29-Aug-91	28	10	20	150	2.615
29-Aug-91	28	10	20	145	2.786
29-Aug-91	28	10	21	181	1.969
29-Aug-91	28	9	20	153	2.337

TABLE A.2. Meristic data collected from bull trout in the Tucannon River in and 1991. Values were entered into Haas's (1988) Dolly Varden/bull trout differentiation formula.

DATE OF COLLECTION	BRANCHIO-STEGAL #	ANAL FIN RAY #	MAXILLARY LENGTH	STAND& LENGTH	FUNCTION
2-Oct-90	26	9	39	254	1.929
2-Oct-90	24	9	24	175	0.057
2-Oct-90	24	9	25	184	0.009
2-Oct-90	26	9	25	201	0.841
2-Oct-90	24	9	39	280	0.137
2-Oct-90	25	10	29	229	9.475
2-Oct-90	27	9	45	304.	2.353
2-Oct-90	26	10	33	210	2.243
30-Jul-90	25	10	35.5	243	1.201
30-Jul-91	26	9	18	134	1.222
24-Jul-91	23	10	13	106	-0.934
24-Jul-91	27	10	20	172	1.346
24-Jul-91	27	11	44	351	1.867
23-Jul-91	27	10	44	351	1.687
1-Aug-91	25	10	38	282	0.778
24-Jul-91	26	9	16	142	0.404
24-Jul-91	26	9	15	123	0.750
24-Jul-91	24	9	14	123	-0.813
24-Jul-91	24	9	19	145	-0.171
24-Jul-91	26	9	13.5	105	0.997
24-Jul-91	26	9	17	138	0.796
24-Jul-91	25	8	17	117	0.811
24-Jul-91	24	9	14	110	-0.311
24-Jul-91	23	9	14	106	-0.762
24-Jul-91	22	9	14	98	-0.990
27-Aug-91	26	10	19	152	1.044
27-Aug-91	24	10	21	168	-0.216
27-Aug-91	26	10	16	125	1.156
27-Aug-91	26	10	16	120	1.355
27-Aug-91	27	10	49	307	2.965

TABLE A.3. **Meristic** data collected from bull trout in the Wolf Fork in 1990 and 1991. Values were entered into Haas's (1988) Dolly Varden/bull trout differentiation formula.

	BRANCHIO-STEGAL #	ANAL FIN RAY #	MAXILLARY LENGTH	STANDARD LENGTH	FUNCTION
16-Jul-90	25	11	SO	370	1.980
22-Jul-90	26	10	15	135	0.526
22-Jul-91	26	9	15	135	0.346
22-Jul-91	25	9	38	258	1.065
18-Jul-91	25	10	41	275	1.313
28-Aug-91	26	10	19	161	0.783
28-Aug-91	26	10	17	124	-1.495
28-Aug-91	26	1 0	18	158	0.631
28-Aug-9 1	26	10	21	169	1.01'6
28-Aug-91	26	10	16	140	0.644
28-Aug-91	25	10	19	148	0.540
28-Aug-91	26	10	17	145	0.754
28-Aug-91	25	10	19	148	0.540
28-Aug-91	26	10	57	410	1.567

TABLE A.4. Meristic data collected from bull trout in Asotin Creek in 1990 and 1991. Values were entered into Haas's (1999) Dolly Varden/bull trout differentiation formula.

	BRANCHIO-STEGAL#	ANAL FIN RAY#	MAXILLARY LENGTH	STANDARD LENGTH	FUNCTION
20-Aug	25	10	19	162	$\boxed{0.126}$

APPENDIX B

SITE SPECIFIC FISH POPULATION ESTIMATES (+ /- C.I.) AND DENSITY (+ /- C.I.) FOR EACH STECIES COLLECTED IN EACH OF THE STUDY STREAMS, 1991.

TABLE B.I.

POPULATION ESTIMATES FOR Y-O-Y BULL TROUT IN MILL CREEK, 1991

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
2	ScRunPool	3	0	69.5	4.3	0
3	Riffle	11	0.2	77.6	14.2	0.26
4	Cascade	12	1.5	56.4	23.8	3
5	Plunge Pool	2	0	46.8	4.3	0
6	Scour Pool	1	0	66.4	1.5	0
7	Riffle	9	1.8	78.6	11.5	2.3
8	Cascade	6	0	139.7	4.3	0
9	Riffle	10	1.9	94.6	10.6	2
10	Cascade	3	0	117	2.6	0
11	Run	2	0	63	3.2	0
12	Scour Pool	3	1.1	92.6	3.2	1.2
13	Riffle	8	7.4	123	6.5	6
14	Plunge	1	0	69.7	1.4	0
15	Cascade	2	0	127	1.6	0
16	Run	1	0	91.5	1.1	0
17	Plunge Pool	0	0	120	0	0
18	Riffle	2	0	203.6	1	0
19	Scour Pool	0	0	155.1	0	0

TABLE B.2.

POPULATION ESTIMATES FOR JUVENILE BULL TROUT IN MILL CREEK, 1991

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Scour Pool	11	2.5	69.5	15.8	3.6
2	Run	3	0	37.6	7.9	0
3	Riffle	10	0	77.6	12.9	0
4	Cascade	4	0	50.4	7.9	0
5	Plunge Pool	9	0	46.8	19.2	0
6	Scour Pool	7	2.1	65.4	10.7	3.2
7	Riffle	8	9	78.6	10.2	1.1
8	Cascade	16	1.9	139.7	11.4	1.4
9	Riffle	8	0.3	94.6	8.5	0.3
10	Cascade	5	0	117	4.3	0
11	Run	8	0	63	12.7	0
12	Scour Pool	8	1.2	92.6	8.6	1.3
13	Riffle	7	0	123	5.7	0
14	Plunge	3	0	69.7	4.3	0
15	Cascade	3	0	127	2.4	0
16	Run	1	0	91.5	1.1	0
17	Plunge Pool	3	0	120	2.5	0
18	Riffle	3	3.2	203.6	1.5	1.6
19	Scour Pool	0	0	155.1	0	0

TABLE 8.3.

POPULATION ESTIMATES FOR Y-d-Y RAINBOW TROUT IN MILL CREEK, 1991

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Scour Pool	1	0	69.5	1.4	0
2	Run	0	0	37.6	0	0
3	Riffle	1	0	77.6	1.3	0
4	Cascade	1	0	50.4	2	0
5	Plunge Pool	3	0	46.8	6.4	0
6	Scour Pool	4	0	65.4	6.1	0
7	Riffle	5	0	78.6	6.4	0
8	Cascade	3	7	139.7	2.1	5
9	Riffle	5	0.6	94.6	5.3	0.63
10	Cascade	8	25	117	6.8	21.4
11	Run	1	0	63	1.6	0
12	Scour Pool	0	0	92.6	0	0
13	Riffle	3	3.2	123	2.4	2.6
14	Plunge	3	3.2	69.7	4.3	4.6
15	Cascade	6	0	127	4.2	0
16	Run	5	1.5	91.5	5.5	1.6
17	Plunge Pool	8	2	120	6.7	1.7
18	Riffle	8	2	203.6	3.9	1
19	Scour Pool	7	8.8	155.1	4.5	5.7

I ABLE 6.4.

POPULATION ESTIMATES FOR JUVENILE RAINBOW TROUT IN MILL CREEK, 1991

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Scour Pool	9	0.9	69.5	12.9	1.3
2	Run	0	0	37.6	0	0
3	Riffle	2	4	77.6	2.6	5.2
4	Cascade	0	0	50.4	0	0
5	Plunge Pool	6	0	46.8	12.8	0
6	Scour Pool	11	2.8	65.4	16.8	4.3
7	Riffle	4	4.5	78.6	5.1	5.7
8	Cascade	8	2.1	139.7	5.7	1.5
9	Riffle	1	0	94.6	1.1	0
10	Cascade	3	0	117	2.6	0
11	Run	1	0	63	1.6	0
12	Scour Pool	7	0.8	92.6	7.6	0.9
13	Riffle	6	0	123	4.9	0
14	Plunge	0	0	69.7	0	0
15	Cascade	6	0	127	4.7	0
16	Run	6	1.2	91.5	6.6	1.3
17	Plunge Pool	12	0	120	10	0
18	Riffle	7	0	203.6	3.4	0
19	Scour Pool	10	0	155.1	6.4	0

TABLE B.5.
POPULATION ESTIMATES FOR Y-O-Y BULL TROUT IN THE WOLF FORK, 1991

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Scour Pool	0	0	20.7	0	0
2	Run	4	1.9	27.7	14.4	6.9
3	Riffle	6	0	66.7	9	0
4	Cascade	2	12	32.7	6.1	36.7
5	Plunge Pool	1	0	15.7	6.4	0
6	Plunge Pool	0	0	26.4	0	0
7	Cascade	1	0	60.8	1.6	0
8	Run	1	0	56.1	1.8	0
9	Riffle	2	0	78	1.3	0
10	Scour Pool	0	0	55.4	0	0
11	Scour Pool	0	0	68	0	0
12	Riffle	0	0	52.5	0	0
13	Cascade	0	0	36.5	0	0
14	Run	0	0	42.8	0	0
15	Plunge Pool	0	0	13.2	0	0
16	Plunge Pool	0	0	29.7	0	0
17	Scour Pool	0	0	87.6	0	0
18	Run	0	0	56.4	0	0
19	Riffle	0	0	88.5	0	0
20	Cascade	0	0	85.2	0	0

TABLE B.6.
POPULATION ESTIMATES FOR JUVENILE BULL TROUT IN ME WOLF FORK 1991.

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Scour Pool	4	1.9	26.7	15	7.1
2	Run	2	0	27.7	7.2	0
3	Riffle	4	0	66.7	1.5	0
4	Cascade	1	0	32.7	3.1	0
5	Plunge Pool	1	0	16.7	6.4	0
6	Plunge Pool	1	0	26.4	3.8	0
7	Cascade	3	0	60.8	4.9	0
8	Run	1	0	56.1	1.8	0
9	Riffle	4	0	78	5.1	0
10	Scour Pool	6	1.7	55.4	10.8	3.1
11	Scour Pool	0	0	68	0	0
12	Riffle	0	0	52.5	0	0
13	Cascade	0	0	36.5	0	0
14	Run	0	0	42.8	0	0
15	Plunge Pool	0	0	13.2	0	0
16	Plunge Pool	0	0	29.7	0	0
17	Scour Pool	0	0	87.6	0	0
18	Run	1	0	56.4	1.8	0
19	Riffle	0	0	88.5	0	0
20	Cascade	0	0	85.2	0	0

TABLE 8.7.

POPULATION ESTIMATE3 FOR Y-O-Y' STEELHEAD TROUT IN THE WOLF FORK, 1991.

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE. AREA (M2)	DENSITY' (#/100M2)	CONFIDENCE INTERVALS
1	Scour Pool	0	0	26.7	0.0	0.0
2	Run	1	0	27.7	0.3	0.0
3	Riffle	0	0	66.7	0.0	0.0
4	Cascade	0	0	32.7	0.0	0.0
5	Plunge Pool	0	0	15.7	0.0	0.0
6	Plunge Pool	2	0	26.4	0.5	0.0
7	Cascade	6	0	60.8	3.6	0.0
8	Run	8	3.3	56.1	4.5	5.9
9	Riffle	8	0.9	78	6.2	1.2
10	Scour Pool	6	2.7	55.4	3.3	4.9
11	Scour Pool	7	1	68	4.8	1.5
12	Riffle	5	0	52.5	2.6	0.0
13	Cascade	1	0	36.5	0.4	0.0
14	Run	6	2.7	42.8	2.6	6.3
15	Plunge Pool	4	0	13.2	0.5	0.0
16	Plunge Pool	5	0	29.7	1.5	0.0
17	Scour Pool	11	2.5	87.6	9.6	2.9
18	Run	5	1.5	56.4	2.8	2.7
19	Riffle	6	1.2	88.5	5.3	1.4
20	Cascade	12	2.3	85.2	10.2	2.7

TABLE 8.8.

POPULATION ESTIMATES FOR JUVENILE STEELHEAD TROUT IN THE WOLF FORK 1991.

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Scour Pool	2	14.7	26.7	0.5	55.1
2	Run	3	0	27.7	0.8	0.0
3	Riffle	3	0	60.7	2.0	0.0
4	Cascade	3	0	32.7	1.0	0.0
5	Plunge Pool	0	0	15.7	0.0	0.0
6	Plunge Pool	12	1.5	26.4	3.2	5.7
7	Cascade	5	1.5	60.8	3.0	2.5
8	Run	5	0	56.1	2.8	0.0
9	Riffle	2	14.7	78	1.6	18.8
10	Scour Pool	18	1.1	55.4	10.0	2.0
11	Scour Pool	7	2.3	68	4.8	3.4
12	Riffle	0	0	52.5	0.0	0.0
13	Cascade	7	1	36.5	2.6	2.7
14	Run	11	1.6	42.8	4.7	3.7
15	Plunge Pool	0	0	13.2	0.0	0.0
16	Plunge Pool	2	14.7	29.7	0.6	49.5
17	Scour Pool	30	5.9	87.6	26.3	6.7
18	Run	12	2.2	56.4	6.8	3.9
19	Riffle	6	1.2	88.5	5.3	1.4
20	Cascade	4	0	85.2	5.4	0.0

TABLE B.9.

POPULATION ESTIMATES FOR Y-O-Y BULL TROUT IN THE TUCANNON RIVER, 1991.

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Cascade	9	9	62.6	14.4	14.4.
2	Run	6	2.7	58.1	10.3	4.6
3	Plunge Pool	1	0	29.9	3.3	0
4	Scour Pool	4	0	35.6	11.2	0
5	Riffle	2	0	66.2	3	0
6	Riffle	2	0	66.1	3	0
7	Plunge Pool	1	0	50.4	2	0
8	Run	1	0	110	0.9	0
9	Casacde	1	0	49.4	2	0
10	Scour Pool	1	0	73.4	1.4	0
11	Run	0	0	62.1	0	0
12	Scour Pool	1	0	53.3	1.9	0
13	Riffle	4	4	51	7.8	7.8
14	Cascade	5	0	41.2	12.1	0
15	Plunge Pool	4	1.9	32.4	12.3	5.9
16	Run	1	0	142.5	0.7	0
17	Riffle	1	0	82.4	1.2	0
18	Plunge Pool	0	0	38.2	0	0
19	Cascade	2	4.8	97.4	1	4.9
20	Scour Pool	1	0	181.1	0.6	0

TABLE B. 10.

POPULATION ESTIMATES FOR JUVENILE BULL TROUT IN THE TUCANNON RIVER, 1991.

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/1 00M2)	CONFIDENCE INTERVALS
1	Cascade	0	0	62.6	0	0
2	Run	2	0	58.1	3.4	0
3	Plunge Pool	0	0	29.9	0	0
4	Scour Pool	1	0	35.6	2.8	0
5	Riffle	1	0	66.2	1.5	0
6	Riffle	0	0	66.1	0	[illegible]
7	Plunge Pool	1	0	50.4	2	0
8	Run	2	0	110	1.8	0
9	Casacde	0	0	49.4	0	0
10	Scour Pool	3	6.2	73.4	4.1	8.4
11	Run	0	0	62.1	0	0
12	Scour Pool	5	0	53.3	9.4	0
13	Riffle	2	0	51	3.9	0
14	Cascade	0	0	41.2	0	0
15	Plunge Pool	1	0	32.4	3.1	0
16	Run	3	0	142.5	2.1	0
17	Riffle	0	0	82.4	0	0
18	Plunge Pool	0	0	38.2	0	0
19	Cascade	2	4.8	97.4	2.1.	4.9
20	Scour Pool	4	3	[illegible]	2.1	[illegible]

TABLE 8.11.

POPULATION ESTIMATES FOR Y-O-Y STEELHEAD TROUT IN THE TUCANNON RIVER, 1991.

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Cascade	2	0	62.6	3.2	0.0
2	Run	0	0	58.1	0.0	0.0
3	Plunge Pool	0	0	29.9	0.0	0.0
4	Scour Pool	3	0	35.6	8.4	0.0
5	Riffle	0	0	66.2	0.0	0.0
6	Riffle	1	0	66.1	1.5	0.0
7	Plunge Pool	2	0	50.4	4.0	0.0
8	Run	2	0	110	1.8	0.0
9	Casacde	1	0	49.4	2.0	0.0
10	Scour Pool	1	0	73.4	1.4	0.0
11	Run	2	25	62.1	3.2	40.3
12	Scour Pool	3	0	53.3	5.6	0.0
13	Riffle	1	0	51	2.0	0.0
14	Cascade	1	0	41.2	2.4	0.0
15	Plunge Pool	3	7.5	32.4	9.3	23.1
16	Run	3	3.2	142.5	2.1	2.2
17	Riffle	4	0	82.4	4.9	0.0
18	Plunge Pool	1	0	38.2	2.6	0.0
19	Cascade	0	0	97.4	0.0	0.0
20	Scour Pool	5	2.4	181.1	2.8	1.3

TABLE B.12.

POPULATION ESTIMATES FOR JUVENILE STEELHEAD TROUT IN THE .TUCANNON RIVER, 1991.

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Cascade	3	0	62.6	4.8	0.0
2	Run	1	0	58.1	1.7	0.0
3	Plunge Pool	4	0	29.9	13.4	0.0
4	Scour Pool	1	0	35.6	2.8	0.0
5	Riffle	6	0	66.2	9.1	0.0
6	Riffle	0	0	66.1	0.0	0.0
7	Plunge Pool	9	6	50.4	17.9	11.9
8	Run	3	3	110	2.7	2.7
9	Casacde	0	0	49.4	0.0	0.0
10	Scour Pool	5	1.5	73.4	6.8	2.0
11	Run	2	25	62.1	3.2	40.3
12	Scour Pool	2	0	53.3	3.8	0.0
13	Riffle	0	0	51	0.0	0.0
14	Cascade	1	0	41.2	2.4	0.0
15	Plunge Pool	8	0.9	32.4	24.7	2.8
16	Run	14	1.3	142.5	9.8	0.9
17	Riffle	0	0	82.4	0.0	0.0
18	Plunge Pool	3	0	38.2	7.9	0.0
19	Cascade	3	3	97.4	3.1	3.1
20	Scour Pool	17	4.5	181.1	9.4	2.5

TABLE B. 13.

POPULATION ESTIMATES FOR JUVENILE SPRING CHINOOK SALMON IN THE TUCANNON RIVER, 1991.

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA (M2)	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Cascade	0	0	62.8	0.0	0.0
2	Run	0	0	58.1	0.0	0.0
3	Plunge Pool	0	0	29.9	0.0	0.0
4	Scour Pool	0	0	35.6	0.0	0.0
5	Riffle	0	0	66.2	0.0	0.0
6	Riffle	0	0	66.1	0.0	0.0
7	Plunge Pool	0	0	50.4	0.0	0.0
8	Run	0	0	110	0.0	0.0
9	Casacde	0	0	49.4	0.0	0.0
10	Scour Pool	0	0	73.4	0.0	0.0
11	Run	0	0	62.1	0.0	0.0
12	Scour Pool	0	0	53.3	0.0	0.0
13	Riffle	0	0	51	0.0	0.0
14	Cascade	0	0	41.2	0.0	0.0
15	Plunge Pool	0	0	32.4	0.0	0.0
16	Run	2	0	142.5	1.4	0.0
17	Riffle	0	0	82.4	0.0	0.0
18	Plunge Pool	6	0	38.2	15.7	0.0
19	Cascade	3	1.1	97.4	3.1	1.1
20	Scour Pool	42	6.2	181.1	23.2	3.4

TABLE B. 14.
BULL TROUT DENSITIES IN ASOTIN CREEK, 1990. THE FORK LENGTH OF AU CAPTURED BULL TROUT ARE REPORTED (## mm). .

SITE #	HABITAT TYPE	SITE AREA (M2)	JUVENILE BT DENSITY (#/100M2)	ADULT ST DENSITY (#/100M2)
1	Pool	21	0	0
2	Riffle	88	0	0
3	Run	70	0	0
4	Pool	73	0	0
5	Riffle	125	0	0
6	Run	77	0	0
7	Pool	69	0	0
8	Riffle	103	0	0
9	Run	78	0	0
10	Run	96	1.0 (229 mm)	0
11	Pool	67	0	1.5 (263 mm)
12	Riffle	93	0	0
13	Run	50	2.0 (186 mm)	2.0 (322 mm)
14	Pool	53	0	2.0 (253mm)
15	Riffle	108	0	0
16	Run	79	0	0

TABLE B.15.
POPULATION ESTIMATES FOR SPRING CHINOOK SALMON IN ASOTIN CREEK, 1990

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Pool	18	0	21	85.7	0
2	Riffle	0	0	88	0.0	0.0
3	Run	1.4	1.4	70	2.0	2.0
4	Pool	0	0	73	0.0	0.0
5	Riffle	0	0	125	0.0	0.0
6	Run	10	0	77	13.0	0.0
7	Pool	13	1.1	69	18.8	1.6
8	Riffle	1	0	103	1.0	0.0
9	Run	0	0	78	0.0	0.0
10	Run	0	0	96	0.0	0.0
11	Pool	47	4.7	67	70.1	7.0
12	Riffle	0	0	93	0.0	0.0
13	Run	6	0	50	12.0	0
14	Pool	0	0	53	0.0	0
15	Riffle	0	0	108	0.0	0
16	Run	0	0	79	0.0	0

TAME B.16.

POPULATION ESTIMATES FOR Y-O-Y STEELHEAD TROUT IN ASOTIN CREEK, 1990.

SITE #	HABITAT TYPE	POPULATION ESTIMATE	CONFIDENCE INTERVALS	SITE AREA	DENSITY (#/100M2)	CONFIDENCE INTERVALS
1	Pool	20	0.5	21	95.2	2.4
2	Riffle	27	1.9	88	30.7	2.2
3	Run	41	13.8	70	58.6	19.7
4	Pool	50	1.2	73	68.5	1.6
5	Riffle	56	1.7	125	44.8	1.4
6	Run	88	3.3	77	114.3	4.3
7	Pool	71	4.1	69	102.9	5.9
8	Riffle	39	1.3	103	37.9	1.3
9	Run	39	1.7	78	50.0	2.2
10	Run	63	1.6	96	65.6	1.7
11	Pool	31	1.8	67	46.3	2.7
12	Riffle	34	1.1	93	36.6	1.2
13	Run	51	0.6	50	102.0	1.2
14	Pool	39	1.5	53	73.6	2.8
15	Riffle	37	1.2	108	34.3	1.1
16	Run	51	1.2	79	64.6	1.5

APPENDIX C

HABITAT UTILIZATION HISTOGRAMS FOR EACH AGE CLASS OF BULL TROUT AND STEELHEAD TROUT SAMPLED IN EACH OF THE STUDY STREAMS, 1991

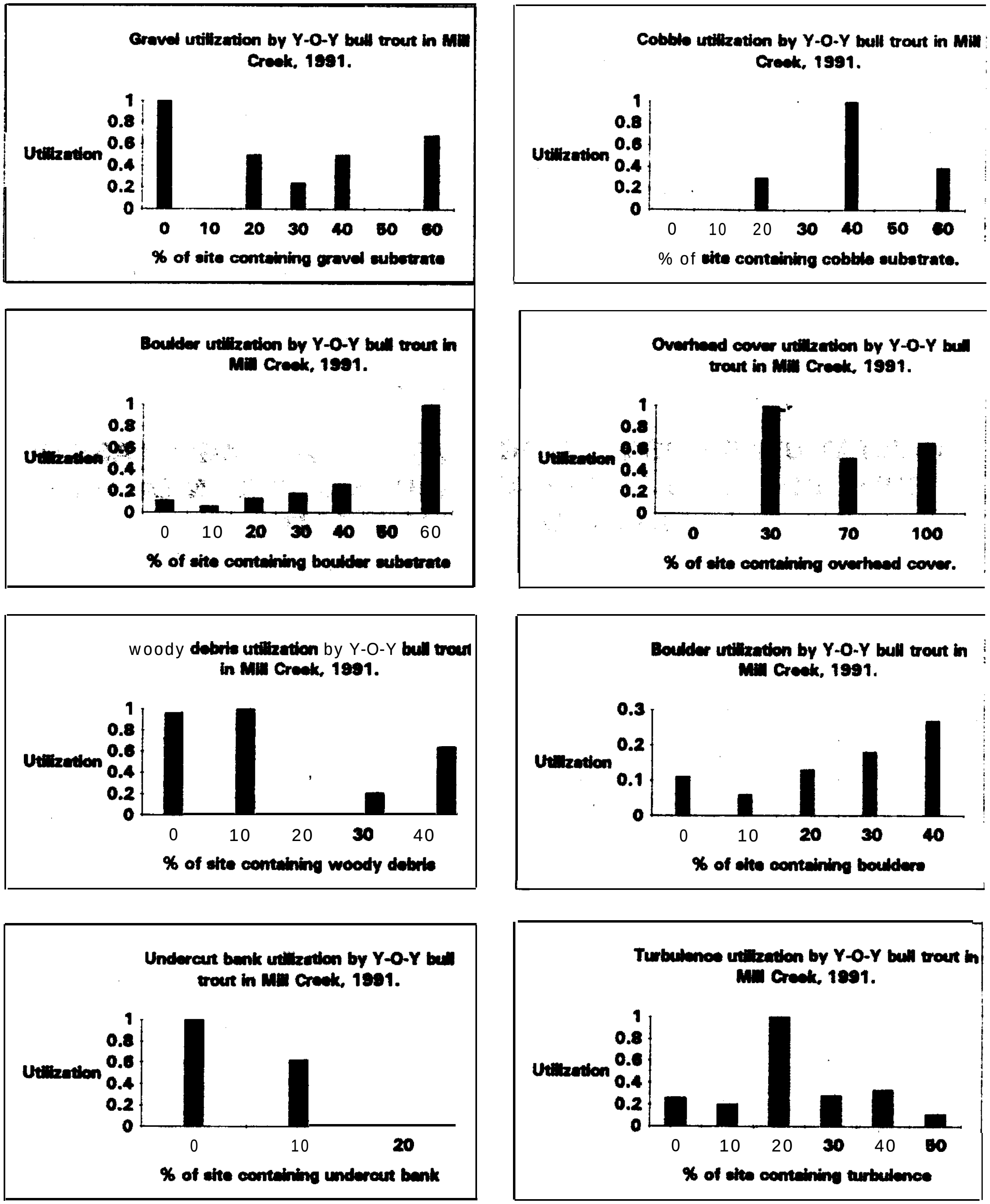

FIGURE C.l. Habitat utilization by YOY bull trout in Mill Creek, 1991.

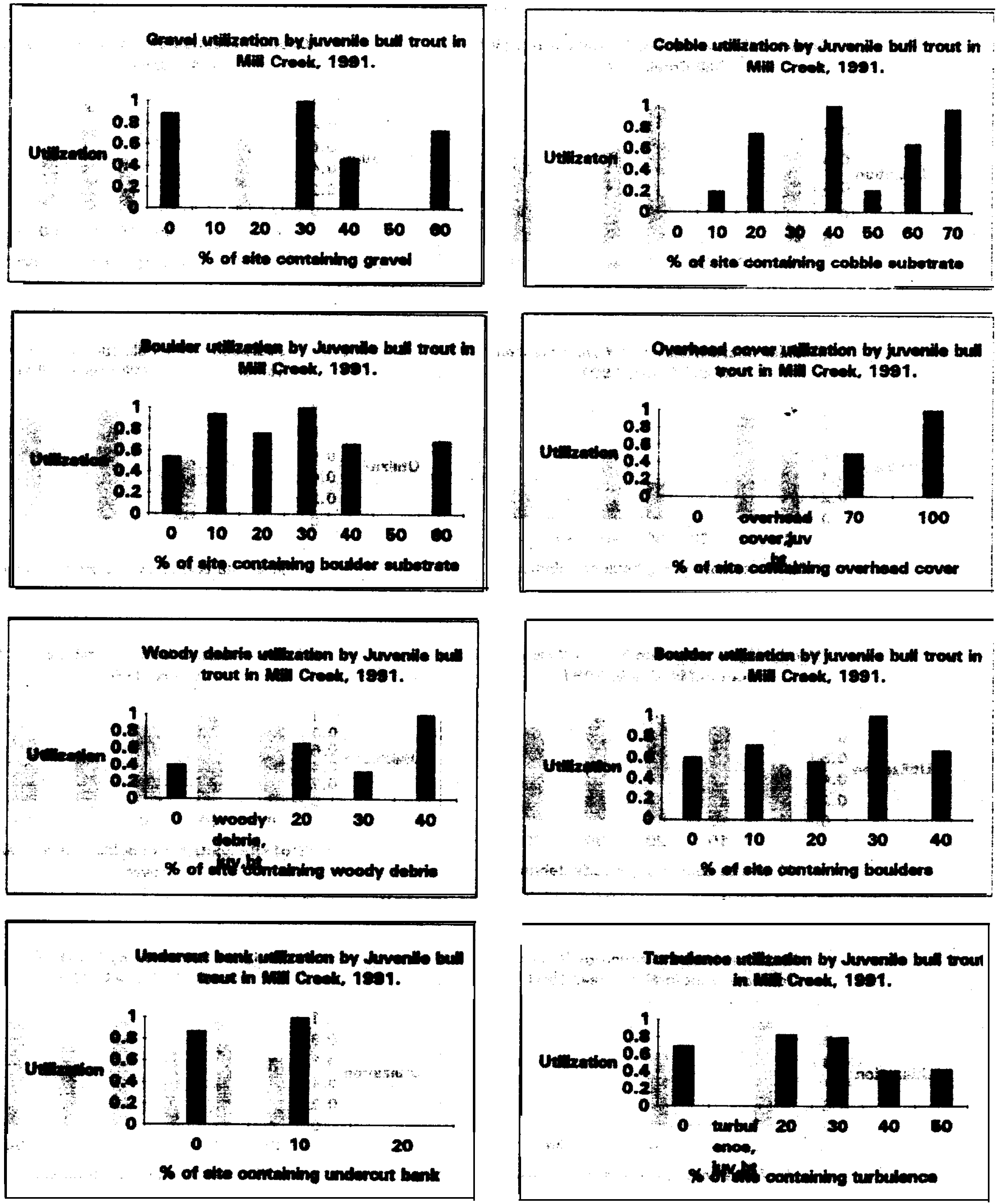

FIGURE C.2. Habitat utilization by juvenile bull trout in Mill Creek, 1991.

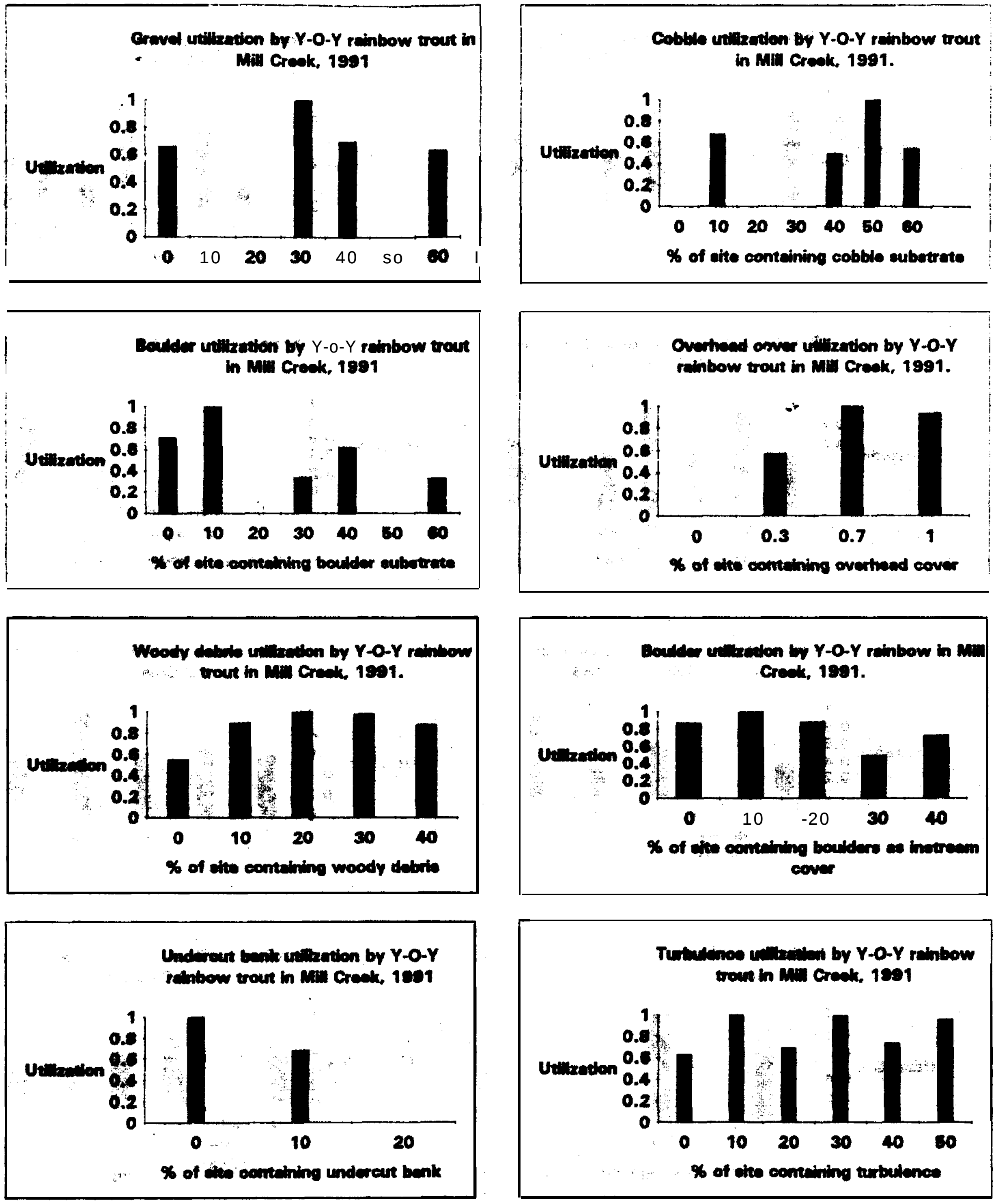

FIGURE C.3 Habitat utilization by YOY rainbow trout in Mill Crook, 1991.

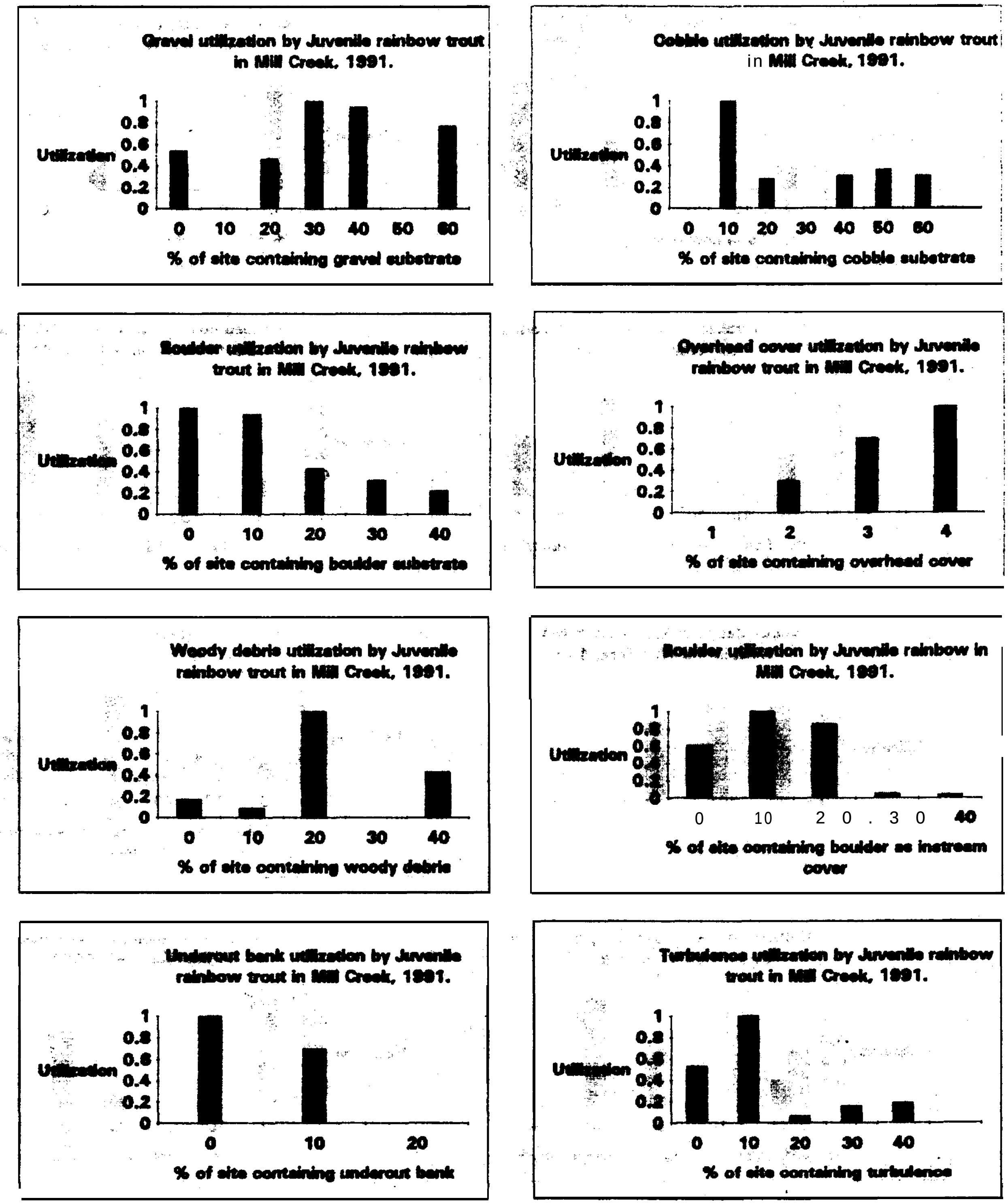

FIGURE C.4. Habitat utilization by juvenile rainbow trout in Mill Creek, 1991.

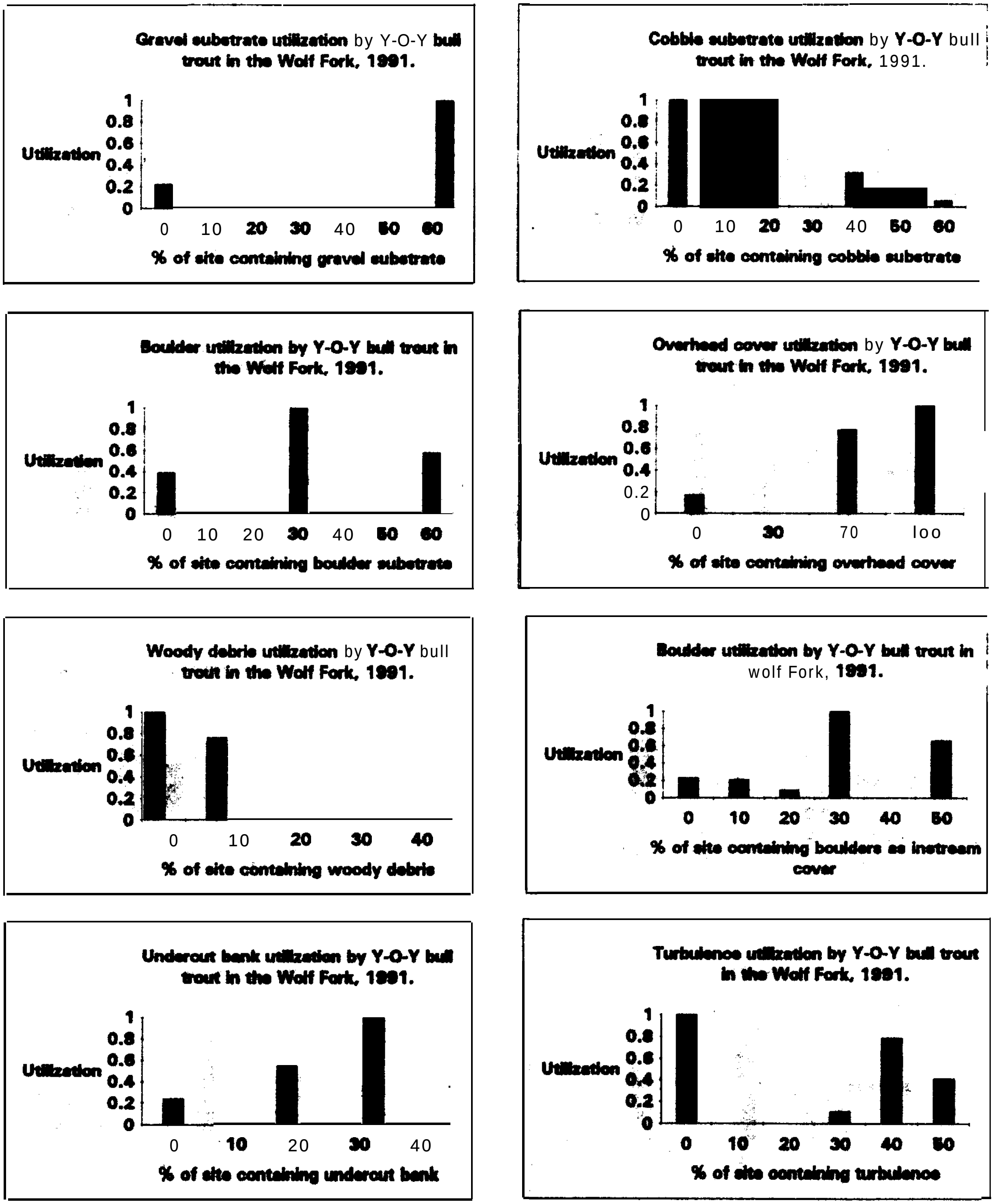

FIGURE C.5. Habitat utilization by YOY bull trout in the Wolf Fork, 1991.

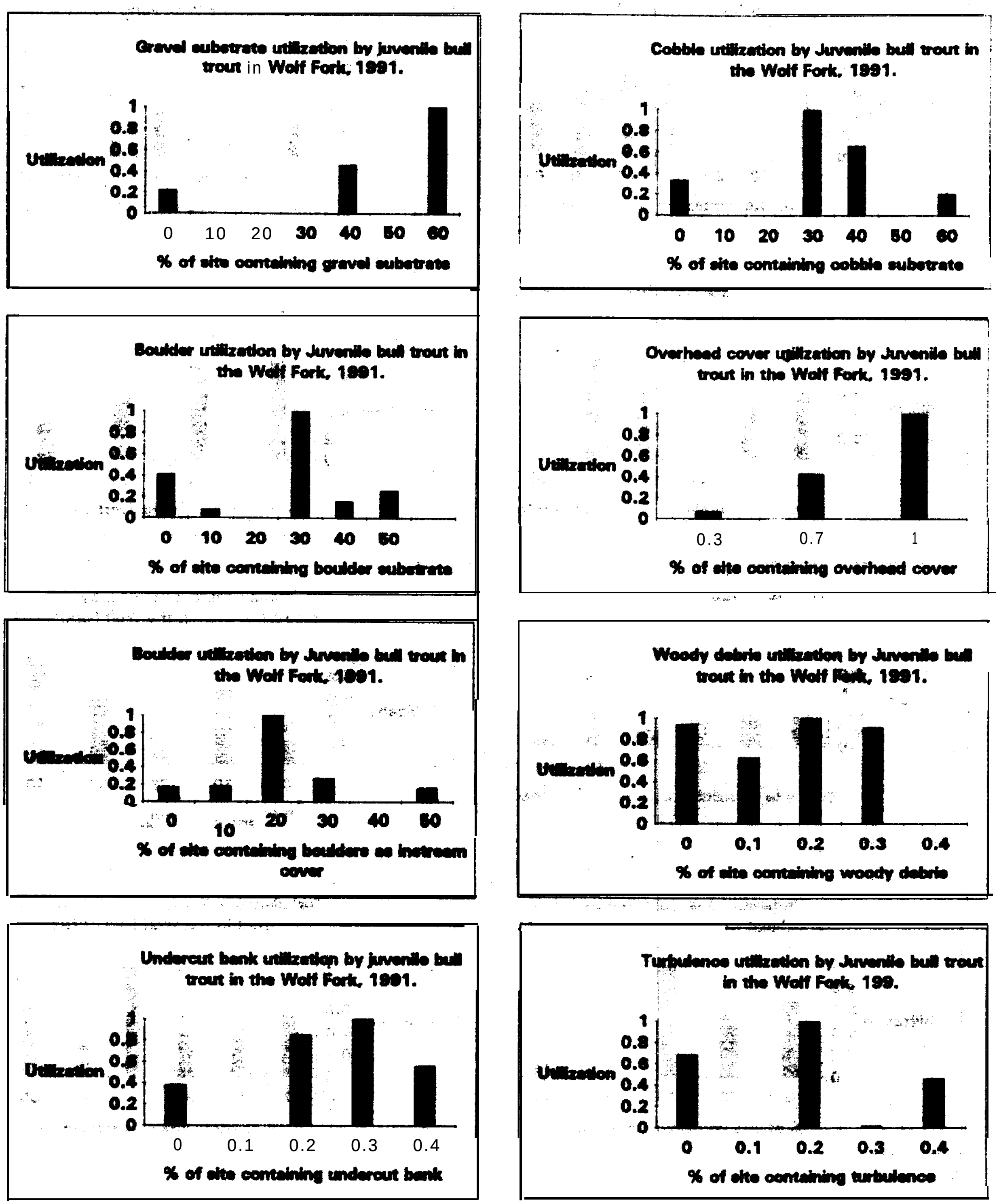

FIGURE C.6. Habitat utilization by juvenile bull trout in the Wolf Fork, 1991.

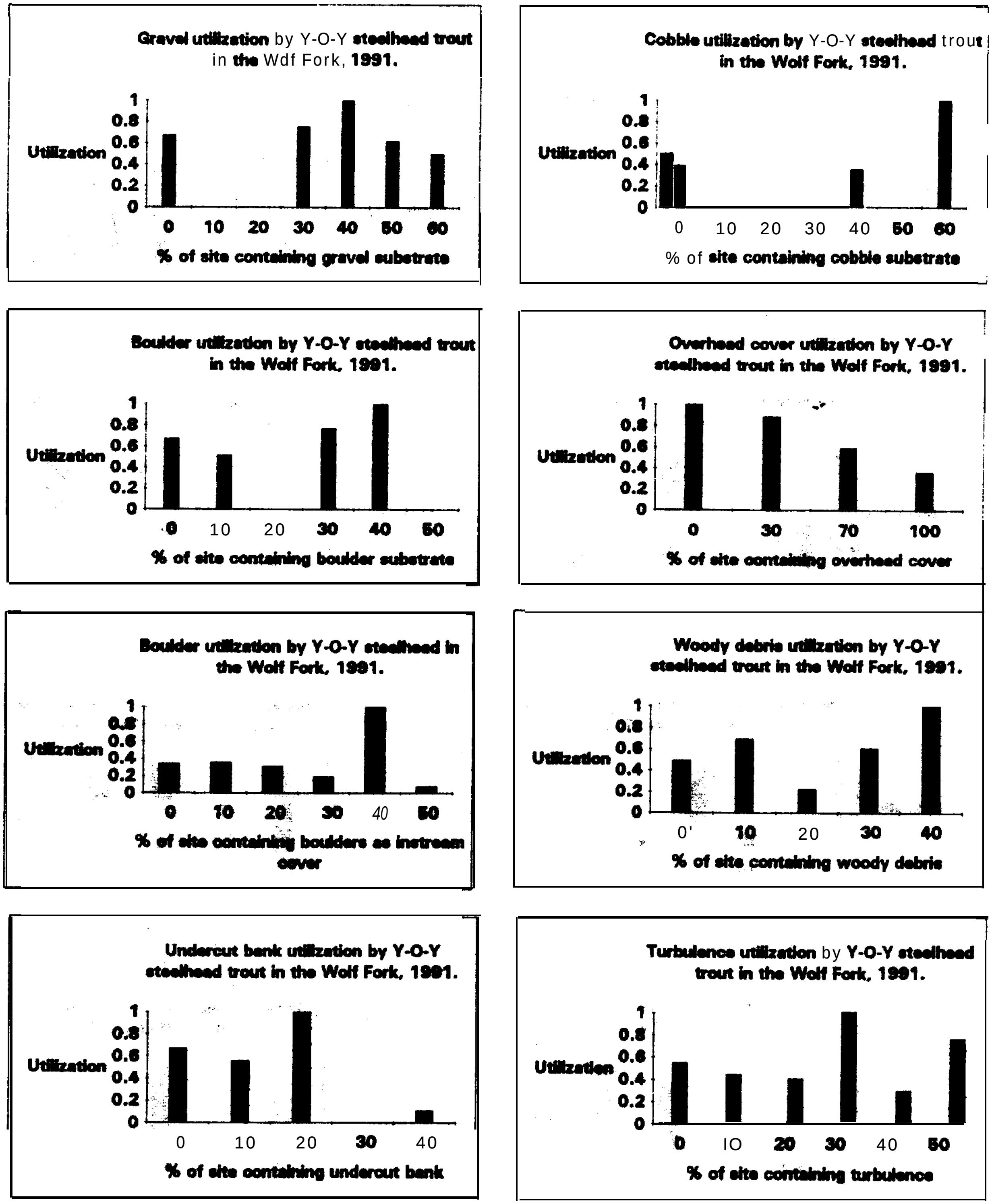

FIGURE C.7. Habitat utilization by YOY steelhead trout in the Wolf Fork, 1991.

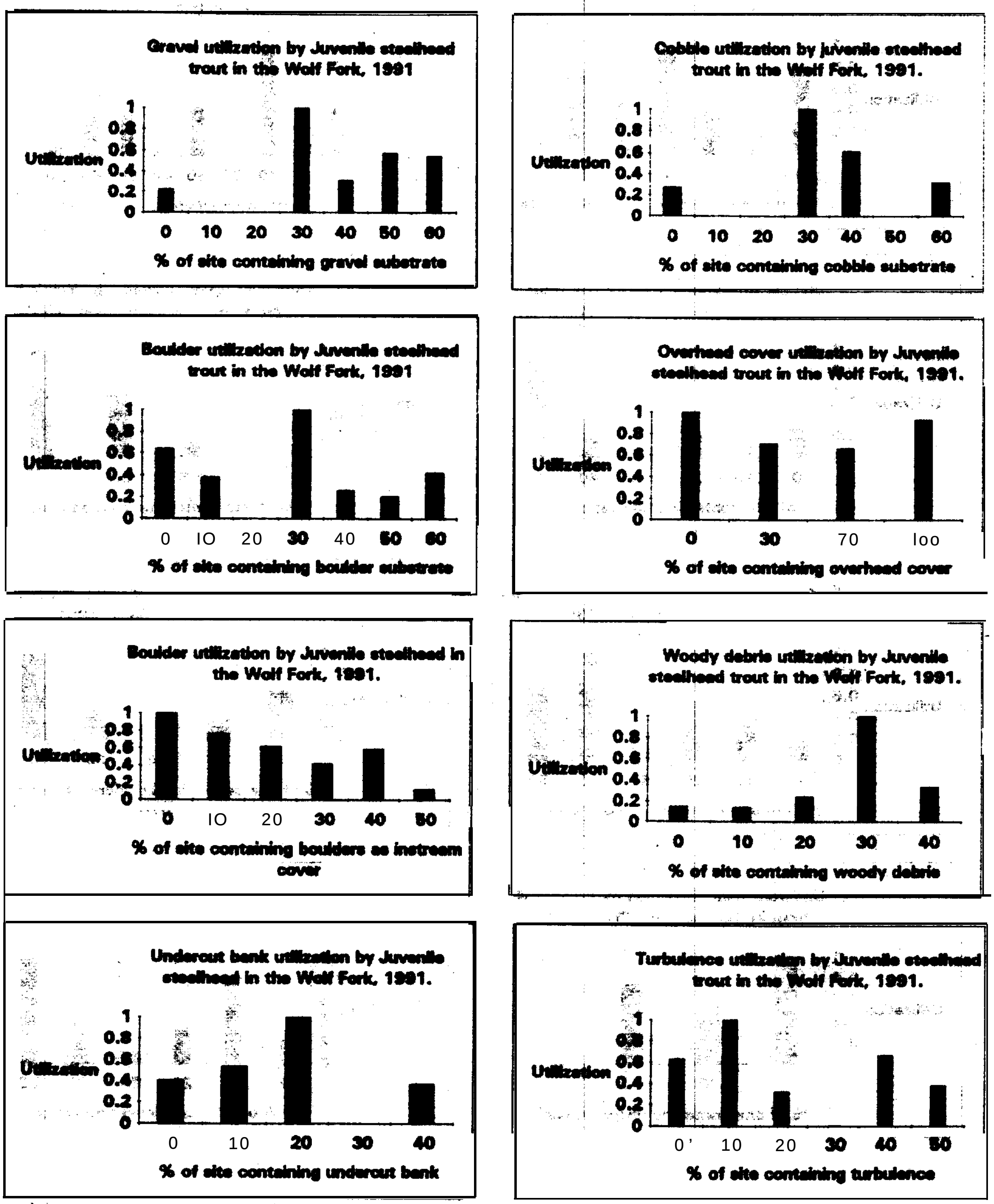

FIGURE C.8. Habitat utilization by juvenile **steelhead** trout in the Wolf **Fork,** 199'

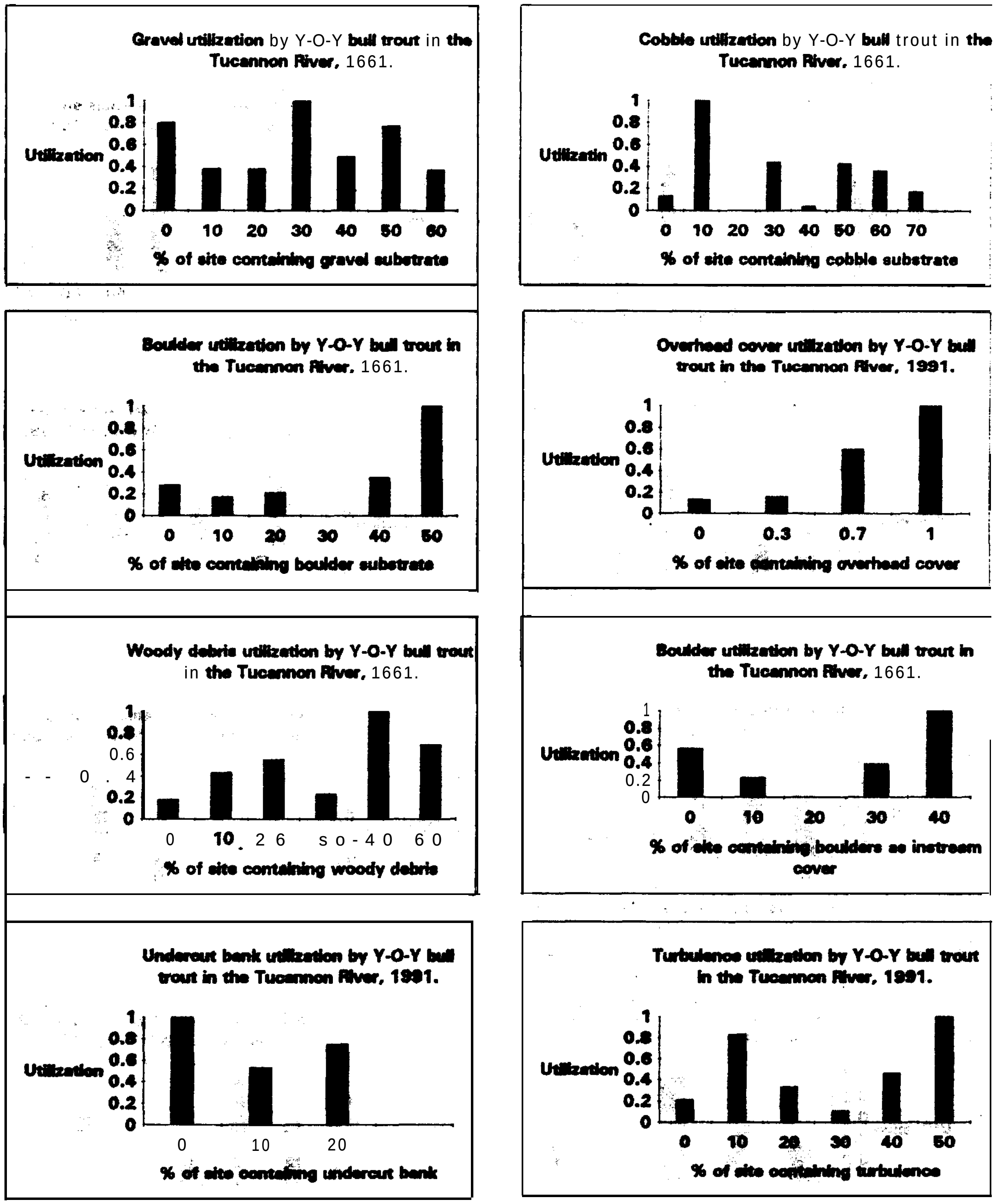

FIGURE C.9. Habitat utilization by YOY bull trout in the Tucannon River, 1991.

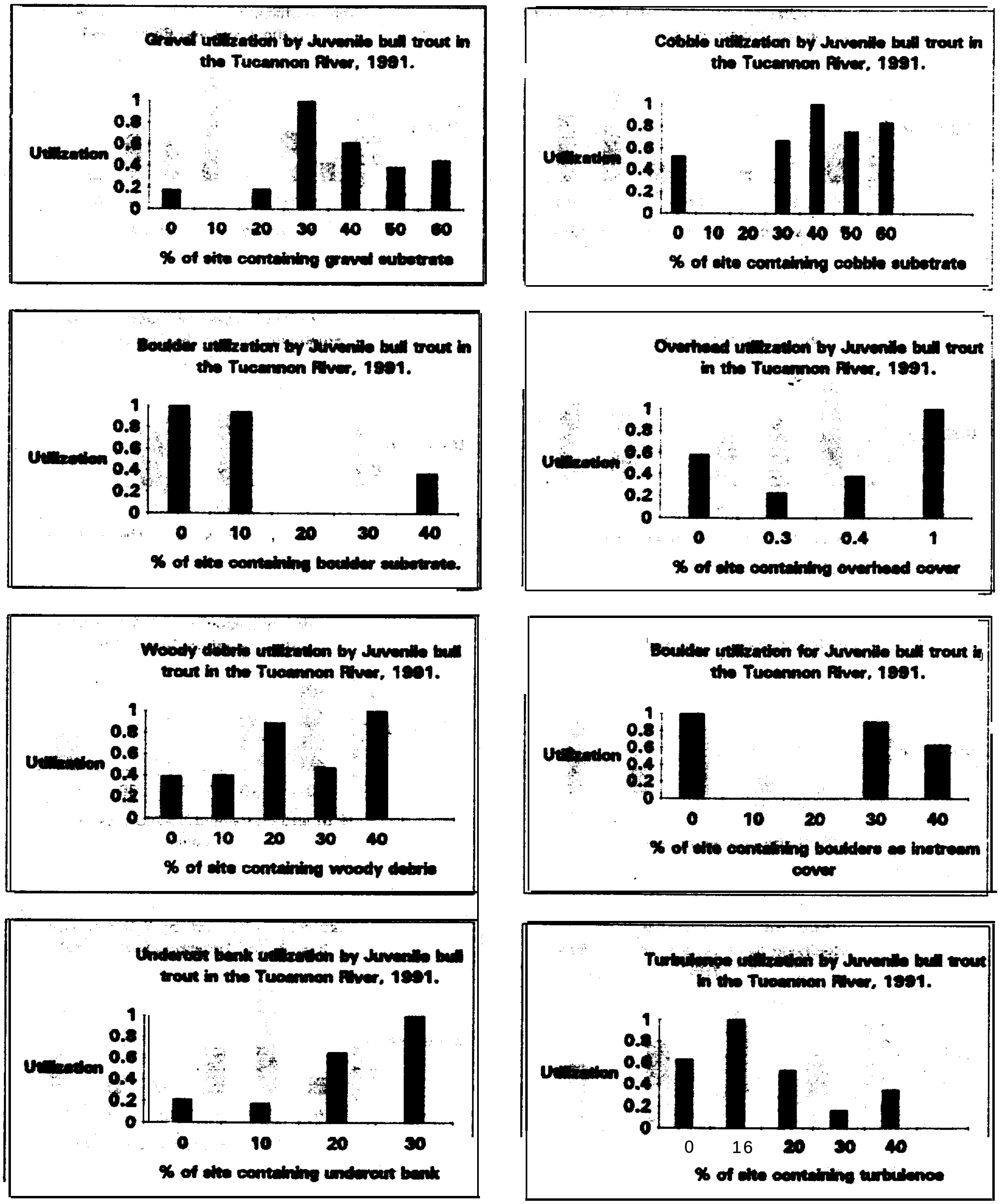

FIGURE C. 10. Habitat utilization by juvenile bull trout in the Tucannon River, 1991

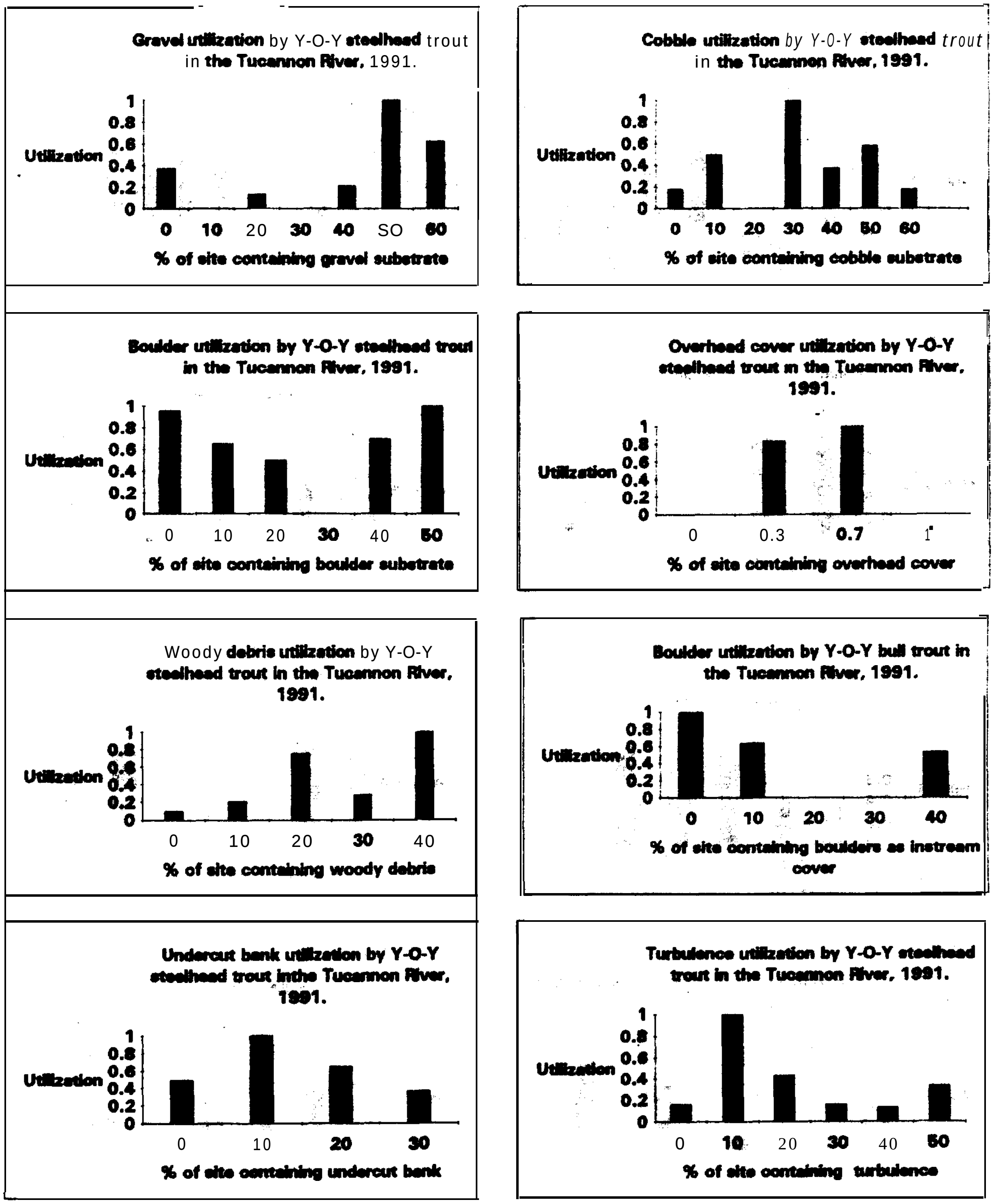

FIGURE C. 11. **Habitat utilization by YOY steelhead trout in the Tucannon River, 1991.**

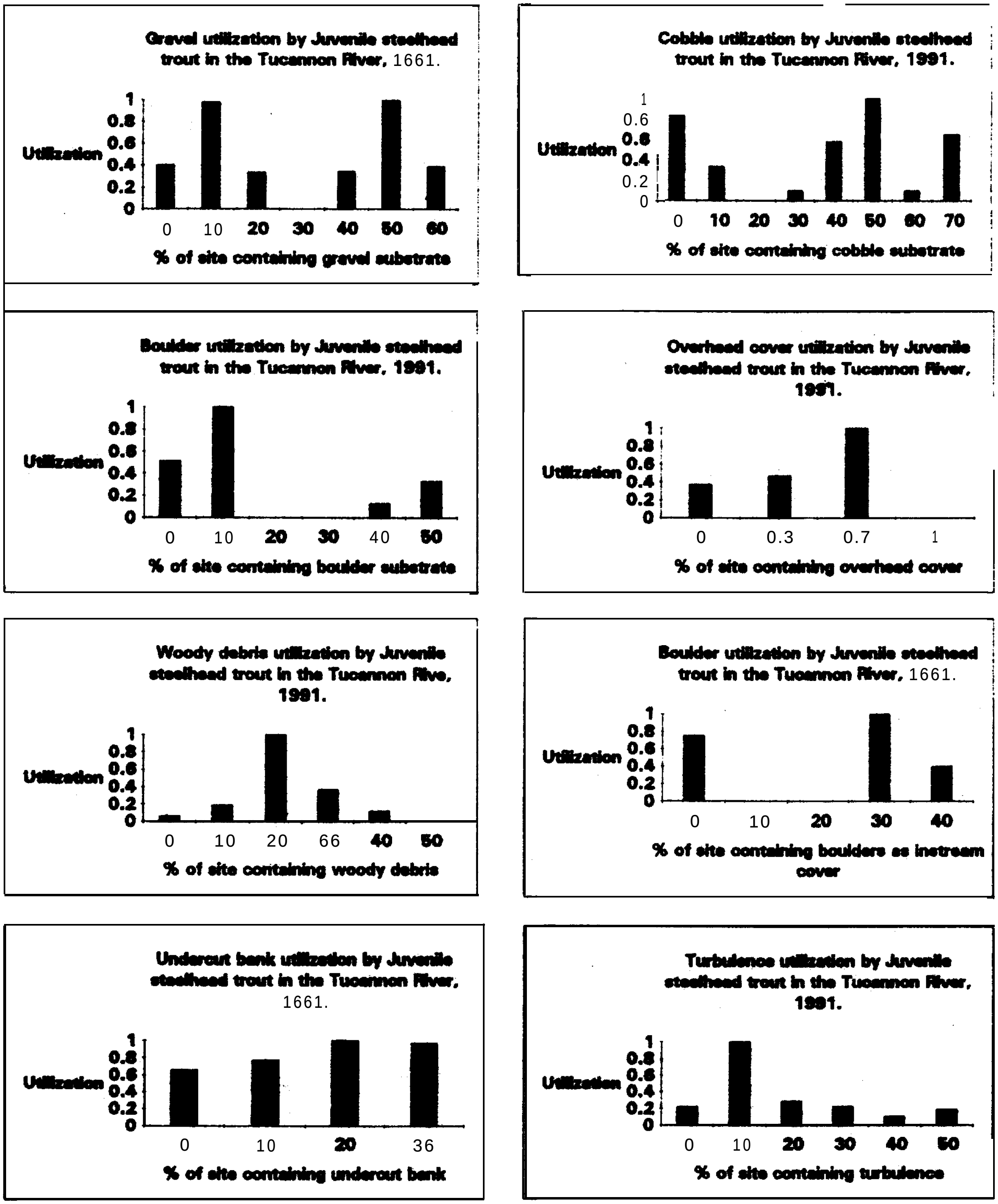

FIGURE C.12. Habitat utilization by juvenile steelhead trout in the Tucanno River, 1991.

APPENDIX D

INVERTEBRATE PRODUCTION

TABLE D.I.

Mill Creek benthic macroinvertebrate samples collected on July 25, 1991. Density (#/sq m.) of each invertebrate is reported.

	SAMPLE # 1 # OF BUGS	DENSITY (#/ so. M)
DIPTERA		
Chronomidae	483	12880
Chironomid pupa	7	187
Ceratopogonidae	2	53
Empididae		27
Pelecorhyohidaa	4	107
Simulidae	23	613
Empidae	1	27
TRICHOPTERA		
Brachycentridae	3	80
Gloesosomatidae		0
Hydropeychiiae		0
Hydroptilidae		0
Lepidostomatidae		0
Leptoceridae	8	213
Limnephilidae		0
Philopotamidae		0
Rhyacophilidae	8	213
Trichop. pupa	1	27
COLEOPTERA		
Dytiscidae		0
Elmidae larva	12	320
Elmidae adult		0
PLECOPTERA		
Ckloroperlidas	88	2347
Nemouridae	2	53
Perlidae	5	133
Perlodidae		0
Pteronarcyidae		0
EPHEMEROPTERA		
Baetidae	136	3627
Ephemerellidae	26	693
Heptageniidae	32	853
Leptophlebiidae		0
OLIGOCHAETA		800
NEMADOTA	18	480
TURBELLARIA		
MOLLUSCA	59	1573
HYDRACARINA	26	693
COPEPODA	1	27
OSTRACODA	43	1147

TABLE 0.2.

Wolf Fork macroinvertebrate percentages for each Order or Class reported. Densities were estimated by taking the average density for the other three stream sampled and using that value for the Wolf Fork.

	MILL CREEK ENVIRONMENT	TUCANNON ENVIRONMENT	ASOTIN ENVIRONMENT	MEAN PERCENTAGE
DIPTERA	0.525	0.346	0.327	0.399
TRICHOPTERA		0.022	0.033	0.025
COLEOPTERA	0.012	0.034	0.088	0.045
PLECOPTERA	0.096	0.101	0.068	0.088
EPHEMEROPTERA	0.195	0.146	0.467	0.266
OLIGOCHAETA	0.03	0.146	0.004	0.06
NEMADOTA	0.018	0.031	0.007	0.019
TURBELLARIA	#REF!	0.176		#REF!
MOLLUSCA	0.059		0.002	0.031
HYDRACARINA		0.027	0.011	0.019
COPEPODA			0.002	0.002

TABLE D.3.

Tucannon River benthic macroinvertabrate samples collected, on July 24, 1991. The mean and standard deviation. of the three samples as well as the density (#/ sq. m) of each invertebrate is reported.

ORGANISMS	SAMPLE # 1 # OF BUGS	SAMPLE x2 # OF BUGS	SAMPLE X3 # OF BUGS	MEAN NUMBER	S.D.	DENSITY (SQ. MI
DIPTERA						
Blepharidae						
Chronomidae	132	36	216	128.0	73.5	3413.3
Chironomid pupa	3	0	2	1.7	1.2	44.4
Ceratopogonidae						
Empididae						
Pelecorhychidae	0	0	16	5.3	7.5	142.2
Rhsgionidar						
Simulidae						
Simulid pupa	2	0	0	0.7	0.9	17.8
Tabsnidss						
Tanyderidae						
Tipulidae	2	0	0	0.7	0.9	17.8
TRICHOPTERA						
Brachycentridae	11	0	4	5.0	4.5	133.3
Glossosomatidae	0	2	9	3.7	3.9	97.8
Helicopsychidae						
Hydropsychidae						
Hydroptilidae						
Lepidostomatidae						
Leptoceridae						
Limnephilidae	0	0	1	0.3	0.5	8.9
Philopotamidae						
Rhyacophilidae	15	4	6	8.3	4.8	222.2
Trichop. pupa						
COLEOPTERA						
Hydrophillidar	0	1	0	0.3	0.5	8.9
Elmidae larva	12	5	52	26.3	25.4	702.2
Elmidae adult						
PLECOPTERA						
Chloroperlidae	20	15	8	14.3	4.9	382.2
Nemouridae	4	8	159	57.0	72.1	1520.0
Perlidae	2	1	15	6.0	6.4	160.0
Perlodidae						
Pteronarcyidae						
EPHEMEROPTERA						
Baetidae	60	20	58	46.0	18.4	1226.7
Ephemereliidae	13	20	32	21.7	7.8	577.8
Heptageniidae	24	29	73	42.0	22.0	1120.0
Leptophlebiidae	0	1	2	1.0	0.8	26.7
Tricorythidae						
OLIGOCHAETA	40	72	220	110.7	78.4	2951.1
NEMADOTA	1	0	69	23.3	32.3	622.2
BIVALVE						
HYDRACARINA	0	1	Z	1.0	0.8	.
COPEPODA						
AMPHIBIAN	1	0	0	0.3	0.5	

TABLE D.4.

Asotin Creek benthic macroinvertabrate samples collected on August 1, 1991. The mean and standard deviation of the three samples as well as the density (#/ sq. m) of each invertebrate is reported.

ORGANISMS	SAMPLE # 1 # OF BUGS	SAMPLE #2 # OF BUGS	SAMPLE #3 # OF BUGS	MEAN NUMBER	S.D.	DENSITY (SQ. M)
DIPTERA						
Blepharidae	5	13	a	8.7	3.3	[illegible]
Chronomidae	47	140	134	107.0	42.5	2853.3
Chironomid pupa	2	6	[illegible]	2.7	[illegible]	[illegible]
Ceratopogonidae						
Empididae						
Pelecorhychidae	cl	6	3	3.9	2.4	80.0
Rhagionidae						
Simulidae	88	98	23	69.7	33.2	1857.8
Simulid pup	2	1	0	1.0	0.8	26.7
Tabanidae						
Tanyderidae						
Tipulidae	2	14	8	8.0	4.3	213.3
TRICHOPTERA						
Brachycentridae	1	15	5	7.0	5.9	186.7
Glossosomatidae	1	0	2	1.0	0.8	26.7
Helicopsychidae						
Hydropsychidae						
Hydroptilidae						
Lepidostomatidae						
Leptoceridae	8	17	5	10.0	5.1	266.7
Limnephilidae	0	0	1	0.3	0.5	8.9
Philopotamidae						
Rhyacophilidae	1	0	3	1.3	1.2	35.6
Trichop. pupa	0	3	0	1.0	1.4	26.7
COLEOPTERA						
Hydrophillidae						
Elmidae larva	18	85	42	48.3	277	1288.9
Elmidae adult	2	13	8	7.7	45	204.4
PLECOPTERA						
Chloroperlidae	2	6	0	2.7	2.5	71.1
Nemouridae	22	24	29	25.0	2.9	666.7
Perlidae	4	13	24	13.7	8.2	364.4
Perlodidae						
Pteronarcyidae	1	1	1	1.0	0.0	
EPHEMEROPTERA						
Baetidae	98	311	273	226.7	93.7	6044.4
Ephemerellidae	1	18	18	12.3	8.0	328.9
Heptageniidae	16	62	57	45.0	20.6	1200.0
Leptophlebiidae	3	3	0	2.0	1.4	53.3
Tricorythidae						
OLIGOCHAETA	0	5	3	27	2.1	11.1
NEMADOTA	2	10	1	4.3	4.0	115.6
BIVALVE	2	2	0	13	0.9	1
HYDRACARINA	4	8	9	7.0	2.2	186.7
COPEPODA	0	4	0	13	1.9	

APPENDIX E

STOMACH CONTENT DATA USED TO DETERMINE THE INDEX OF RELATIVE IMPORTANCE, DIET OVERLAP, AND ELECTIVITY INDICES FOR BULL TROUT, STEELHEAD TROUT, AND SPRING CHINOOK SALMON, 1991.

TABLE E.1.

Diet analysis of 10 juvenile (100 < x < 250 mm FL) bull trout collected from Mill Creek, July 27, 1991. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCURREN.
DIPTERA					
Chironomidae	5	5.56%	0.001	0.1%	0.5
Chironomid pupa	1	1.11%	0.0007	0.07%	0.1
Chironomid adult	1	1.11%	0.0001	0.01%	0.1
Empididae	0		0		
Pelecorhychidae	4	4.44%	0.0001	0.01%	0.1
Simulidaa	1	1.11%	0.0005	0.05%	0.1
Simulid pupa	0		0		
Tabanidae	0		0		
Tipulidae	0		0		
TRICHOPTERA	0		0		
Brachycentridae	0		0		
Glossosomatidse	3	3.33%	0.0053	0.53%	0.1
Hslicopsychidae	0		0		
Hydropsyohidas	0		0		
Lepidostometidae	0		0		
Leptoceridae	0		0		
Limnephilidae	0		0		
Rhyacophilidae	1	1.11%	0.0001	0.01%	0.1
Hydrophilidae	0		0		
COLEOPTERA	0		0		
Hydrophilidae	0		0		
Elmidae larva	0		0		
Elmidae adult	0		0		
Carabidae	1	1.11%	0.01	1.%	0.1
PLECOPTERA	0		0		
Chloroperlidae	1	1.11%	0.0001	0.01%	0.1
Perlidae	14	15.56%	0.7987	80.21%	0.9
Pteronarcyidae	0		0		
EPHEMEROPTERA					
Baetidae	30	33.33%	0.0019	0.19%	0.9
Ephemerellidae	3	3.33%	0.0011	0.11%	0.3
Heptageniidae	6	6.67%	0.0025	0.25%	0.4
Leptophlebiidae	0		0		
OLIGOCHAETA	5	6.56%	00022	0.22%	0.1
TURBELLARIA	2	2.22%	00001	001%	0.1
MOLLUSCA	1	1.11%	0.0001	0.01%	0.1
HYDRACARINA	0		0		
TERRESTRIALS	5	. %	0.0008	0.08%	0.3
LEPIDOPTERA	2	2.22%	0 . 0202	2 , 03%	0.1
UNIDENTIFIED PARTS	3	3.33%	0.0003	003%	0.2
COTTIDAE	1	. %	0.15	15.06%	0.1

TABLE E.2.

Diet analysis of 10 juvenile (100 mm < x < 250 mm FL) bull trout collected from Mill Creek, August 28, 1991. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCUR.
DIPTERA					
Chironomidae	3	2.07%	0.004	0.25%	0.3
Chironomid pupa	0		0		
Chironomid adult	0		0		
Empididae	0		0		
Pelecorhychidae	0		0		
Bimulidaa	2	1.38%	0.0026	0.16%	0.2
Simulid pupa	0		0		
Tabanidae	0		0		
Tipulidae	0		0		
TRICHOPTERA	0		0		
Brachycentridae	0		0		
Glossosomatidae	1	0.69%	0.0048	0.3%	0.1
Helicopsychidae	0		0		
Hydropsychidae	0		0		
Lepidostomatidae	0		0		
Leptoceridae	0		0		
Limnephilidae	0		0		
Rhyacophilidae	0		0		
Hydrophilidae	0		0		
COLEOPTERA	0		0		
Hydrophilidae	0		0		
Elmidae larva	0		0		
Elmidae adult	0		0		
Carabidae	0		0		
PLECOPTERA	0		0		
Chloroperlidae	0		0		
Perlidae	7	4.83%	0.076	4.81%	0.6
Pteronarcyidae	0		0		
EPHEMEROPTERA					
Baetidae	110	75.86%	0.06	3.8%	0.6
Ephemerellidae	5	3.45%	0.0071	0.45%	0.3
Heptageniidae	3	2.07%	0.0004	0.03%	0.2
Leptophlebiidae	0		0		
OLIGOCHAETA	0		0		
TURBELLARIA	0		0		
MOLLUSCA	0		0		
HYDRACARINA	0		0		
TERRESTRIALS	7	4.83%	0.0121	0.77%	0.4
LEPIDOPTERA	2	1.38%	0.016	1.01%	0.2
UNIDENTIFIED PARTS	0		0		
COTTIDAE	5	.45%	1.3968	88.42%	.

Table E.3.

Diet anslysis of 10 juvenile (100 < x < 250 mm FL) rainbow trout collected from the Wolf Fork River, July 25, 1991: The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCUR.
DIPTERA					
Chironomidae	4	4.12%	0.0001	0.01%	0.1
Chironomid pupa	0		0		
Chironomid adult	0		0		
Empidiiaa	0		0		
Pelecorhychidae	2	2.06%	0.0002	0.02%	0.2
Simulidae	0		0		
Simulid pupa	0		0		
Tabanidae	0		0		
Tipulidae	0		0		
TRICHOPTERA	0		0		
Brachycentridae	0		0		
Glossosomatidae	1	1.03%	0.0028	0.35%	0.1
Helicopeychidae	0		0		
Hydropsychidae	2	2.06%	0.0009	0.11%	0.1
Lepidostomatidae	0		0		
Leptoceridw	0		0		
Limnephilidae	5	5.15%	0.0078	0.97%	0.1
Rhyacophiliiae	0		0		
COLEOPTERA	0		0		
Hydrophilidae	0		0		
Elmidae larva	0		0		
Elmidw adult	1	1.03%	0.0001	0.01%	0.1
Gyrinidae	1	1.03%	0.0001	0.01%	0.1
PLECOPTERA	0		0		
Chloroperlidae	0		0		
Perlidae	5	5.15%	0.0676	8.42%	0.5
Pteronarcyidae	0		0		
EPHEMEROPTERA					
Baetidae	37	38.14%	0.0038	0.47%	0.6
Ephemerellidae	4	4.12%	0.0034	0.42%	0.2
Heptageniidae	14	14.43%	0.0607	7.57%	0.7
Leptophlebiidae	0		0		
OLIGOCHAETA	0		0		
TURBELLARIA	0		0		
HYDRACARINA	0		0		
TERRESTRIALS	17	17.53%	0.0336	4.19%	0.7
LEPIDOPTERA	2	2.06%	0.0107	1.33%	0.1
UNIDENTIFIED PARTS	1	1.03%	0.0014	0.17%	
GASTROPODA	1	%	0.6088	75.92%	
COTTIDAE	0		0		

TABLE E.4.

Diet analysis of 12 juvenile (100 < x < 250 mm FL) rainbow trout collected from Mill Creek, August 28, 1991. Tha number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCURREN.
DIPTERA					
Chironomidae	9	2.28%	0.003	0.11%	0.42
Chironomid pupa	0		0		
Ceratopogonidae	0		0		
Empididae	1	0.25%	2	71.45%	0.08
Pelecorhychidae	0		0		
Simulidae	6	1.52%	0.0043	0.15%	0.42
Simulid pupa	0		0		
Tabanidae	0		0		
Tipulidae	0		0		
TRICHOPTERA	0		0		
Brachycentridae	2	0.51%	0.0016	0.06%	0.17
Glossosomatidae	3	0.76%	0.0398	1.41%	0.25
Helicopsychidae	0		0		
Hydropsychidae	0		0		
Lepidostomatidae	0		0		
Leptoceridae	0		0		
Limnephilidae	3	0.76%	0.0005	0.02%	0.08
Rhyacophilidae	1	0.25%	0.0023	0.08%	0.17
Hydrophilidae	0		0		
COLEOPTERA	0		0		
Hydrophilidae	4	1.01%	0.0036	0.13%	0.25
Elmidae larve	0		0		
Elmidae adult	1	0.25%	0.0055	0.2%	0.08
Amphizoidae	0		0		
PLECOPTERA	0		0		
Nemouridae	12	3.04%	0.004	0.14%	0.42
Perlidae	4	1.01%	0.0644	2.3%	0.33
Pteronarcyidae	0		0		
EPHEMEROPTERA					
Baetidae	261	66.08%	0.0399	1.43%	0.75
Ephemerellidae	1	0.25%	0.0008	0.03%	0.08
Heptageniidae	11	2.78%	0.0074	0.26%	0.5
Leptophlebiidae	0		0		
OLIGOCHAETA	0		0		
TURBELLARIA	0				
MOLLUSCA	0				
HYDRACARINA	1	0.25%	0.0001	0.%	0.17
TERRESTRIALS	63	15.95%	0.5219	18.64%	0.83
LEPIDOPTERA		2.53%	0.0904	3.23%	0.33
UNIDENTIFIED PARTS	2	0.51%	0.0098	0.35%	.08
COTTIDAE	0		0		

TABLE E.5.

Diet analysis of 8 juvenile (100 mm < x < 250 mm FL) bull trout collected from the Wolf Fork River, July 23, 1991. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCURREN.
DIPTERA					
Chironomidw	5	7.81%	0.0008	0.14%	0.25
Chironomid pupa	1	1.56%	0.0001	0.02%	0.13
Ceratopogonidae	0		0		
Empididw	0		0		
Pelecorhychidae	0		0		0.1
Simulidae	0		0		0.3
Bimulid pupa	0		0		
Culcidaa	0		0		
Tipulidae	0		0		
TRICHOPTERA					
Brachycentridae	1	1.56%	0.0001	0.02%	0.13
Glossosomatidas	2	3.13%	0.0001	0.02%	0.13
Helicopsychidae	0		0		
Hydropsychidw	11	17.19%	0.0767	18.51%	0.63
Lepidostomatidas	0		0		
Leptoceridae	1	1.56%	0.0001	0.02%	0.13
Limnephilidae	0		0		0.1
Rhyacophiiidw	2	3.13%	0.0048	1.16%	0.13
COLEOPTERA	0		0		
Hydrohilidae	0		0		
Elmidae larva	0		0		
Elmidae adult	0		0		
Amphizoidae	1	1.56%	0	0.%	0.13
PLECOPTERA	0		0		
Nemouridae	0		0		
Perlidae	11	17.19%	0.3012	72.68%	0.63
Pteronarcyidae	0		0		
EPHEMEROPTERA	0		0		
Baetidae	9	14.06%	0.0042	1.01%	0.63
Ephemerellidae	10	15.63%	0.0052	1.25%	0.5
Heptageniidae	3	4.69%	0.0013	0.31%	0.38
Leptophlebiidae	0		0		
OLIGOCHAETA	0		0		
TURBELLARIA	1	. %	0.0003	0.07%	0.13
MOLLUSCA	0		0		
HYDRACARINA	0		0		
TERRESTRIALS	2	. %	0.0063	1.52%	. . 5
LEPIDOPTERA	1	1.56%	0.0001	0.02%	.
UNIDENTIFIED PARTS	3	.69%	.	3.21%	0.25
COTTIDAE	0		0		

TABLE **E.6.**

Diet analysis of 11 **juvenile** (100 mm < x c 250 mm FL) **bull** trout **collected** from the **Wolf Fork River, August 28, 1991**. The number and weight **(g)** of **each** organism found in each stomach **is reported.**

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCUR.
DIPTERA					
Chironomidae	32	19.51%	0.0251	2.52%	0.73
Chironomid pupa	1	0.61%	0.0006	0.06%	0.09
Chironomid adult	0		0		
Empididae	1	0.61%	0.0001	0.01%	0.09
Pelecorhynchidae	3	1.83%	0.0038	0.38%	0.27
Simuliidae	1	0.61%	0.0048	0.48%	0.09
Simulid pupa	0		0		
Tabanidae	0		0		
Stratiomyidae	1	0.61%	0.0031	0.31%	0.09
TRICHOPTERA	0		0		
Brachycentridae	0		0		
Glossosomatidae	2	1.22%	0.0012	0.12%	0.18
Helicopsychidae	0		0		
Hydropsychidae	2	1.22%	0.0049	0.49%	0.18
Lepidostomatidae	0		0		
Leptoceridae	5	3.05%	0.0122	1.22%	0.36
Limnephilidae	0		0		
Rhyacophilidae	4	2.44%	0.0094	0.94%	0.36
COLEOPTERA	0		0		
Hydrophilidae	2	1.22%	0.0021	0.21%	0.18
Elmidae larva	0		0		
Elmidae adult	2	1.22%	0.0918	9.21%	0.18
Gyrinidae	0		0		
PLECOPTERA	0		0		
Chloroperlidae	1	0.61%	0.0015	0.15%	0.09
Perlidae	12	7.32%	0.2316	23.24%	0.73
Pteronarcyidae	0		0		
EPHEMEROPTERA					
Baetidae	45	27.44%	0.019	1.91%	0.82
Ephemerellidae	12	7.32%	0.0396	3.97%	0.55
Heptageniidae	15	9.15%	0.0356	3.57%	0.45
Leptophlebiidae	0		0		
OLIGOCHAETA	1	0.61%	0.0089	0.89%	0.09
TURBELLARIA			0		
HYDRACARINA	1	0.61%	0.0006	0.06%	0.09
TERRESTRIALS	19	11.59%	0.027	2.71%	0.55
LEPIDOPTERA	0		0		
UNIDENTIFIED PARTS	1	0.61%	0.0028	0.28%	0.09
GASTROPODA	0		0		
COTTIDAE	1	0.61%	0.4708	47.26%	0.09

TABLE E.7.

Diet analysis of 1 1 juvenile (100 mm < x < 250 mm FL) steelhead trout collected from the Wolf Fork River, July 23, 1991. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCURREN.
DIPTERA					
Chironomidae	15	13.51%	0.0673	11.84%	0.45
Chironomid pupa	2	1.8%	0.0001	0.02%	0.09
Ceratopogonidae	1	300.%	0.0001	0.02%	0.09
Empididae	0		0		
Pelecorhychidae	1	0.9%	0.0003	0.05%	0.09
Simulidae	0		0		
Simulid pupa	1	0.9%	0.0001	0.02%	0.09
Culcidae	0		0		
Tipulidae	0		0		
TRICHOPTERA					
Brachycentridae	1	0.9%	0.0006	0.11%	0.09
Glossosomatidae	6	5.41%	0.033	5.8%	0.27
Helicopsychidae	0		0		
Hydropsychidae	13	11.71%	0.0725	12.75%	0.36
Lspidoetomatidw	0		0		
Leptoceridae	3	2.7%	0.0002	0.04%	0.27
Limnephilidw	2	1.8%	0.0163	2.87%	0.09
Rhyacophilidae	6	5.41%	0.0283	4.98%	0.27
			0		
COLEOPTERA	0		0		
Hydrohilidw	0		0		
Elmidae larva	0		0		
Elmidae adult	0		0		
Culculionidae	1	0.9%	0.0012	0.21%	0.09
PLECOPTERA	0		0		
Chloroperlidae	1	0.9%	0.0378	6.65%	0.09
Perlidae	5	4.5%	0.2427	42.69%	0.36
Pteronarcyidae	0		0		
EPHEMEROPTERA	0		0		
Baetidae	6	5.41%	0.0028	0.49%	0.55
Ephemerellidae	23	20.72%	0.0353	6.21%	0.91
Heptageniidae	6	5.41%	0.003	0.53%	0.45
Leptophlebiiiae	0		0		
OLIGOCHAETA	0		0		
TURBELLARIA	0		0		
MOLLUSCA	1	0.9%	0.0001	0.02%	0.09
HYDRACARINA	0		0		
TERRESTRIALS	10	9.01%	0.0079	1.39%	0.36
LEPIDOPTERA	2	1.8%	0.0092	1.62%	0.09
UNIDENTIFIED PARTS	5	.5%	0.0097	1.71%	.45
COTTIDAE	0		0		0

TABLE E.8.

Diet analysis of 9 juvenile (100mm < x < 250 mm FL) steelhead trout collected from the Wolf Fork River, August 28. 1991. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCUR.
DIPTERA					
Chironomidae	14	6.67%	0.0129	1.3%	0.56
Chironomid pupa	0		0		
Chironomid adult	0		0		
Ceratopagonadiae	0		0		
Pelecorhychidae	1	0.48%	0.0048	0.48%	0.111
Simulidae	0		0		
Simulid pupa	0		0		
Tabanidae	0		0		
Stratiomyidae	0		0		
TRICHOPTERA					
Brachycentridae	5	2.38%	0.0034	0.34%	0.22
Glossosomatidae	0		0		
Helicopsychidae	0		0		
Hydropsychidae	9	4.29%	0.1171	11.79%	0.44
Lepidostomatidae	0		0		
Leptoceridae	5	2.38%	0.0084	0.85%	0.33
Limnephilidae	0		0		
Rhyacophilidae	1	0.48%	0.0014	0.14%	0.11
COLEOPTERA	0		0		
Hydrophilidae	0		0		
Elmidae larva	0		0		
Elmidae adult	0		0		
Curculionidae	1	0.48%	0.0043	0.43%	0.11
PLECOPTERA	0		0		
Chloroperlidae	1	0.48%	0.0009	0.09%	0.11
Perlidae	8	3.81%	0.1538	15.48%	0.44
Pteronarcyidae	1	0.48%	0.1179	11.87%	0.11
EPHEMEROPTERA					
Baetidae	74	35.24%	0.0268	2.7%	0.89
Ephemerellidae	29	13.81%	0.1084	10.91%	0.67
Heptageniidae	10	4.76%	0.0449	4.52%	0.22
Leptophlebiidae	0		0		
OLIGOCHAETA	0		0		
MOLLUSCA	0		0		
HYDRACARINA	0		0		
TERRESTRIALS	64	30.48%	0.398	40.06%	0.78
LEPIDOPTERA	1	0.48%	0.0037	0.37%	0.11
UNIDENTIFIED PARTS	0		0		
GASTROPODA	0		0		
COTTIDAE	0		0		

TABLE E.9.

Diet analysis of 10 juvenile (100 mm < x < 250 mm FL) bull trout collected from the Tucannon River, July 24, 1991. The number and weight (g) of each" organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT	FREQ. OF OCCURREN.
DIPTERA					
Chironomidae	4	3.54%	0.0003	0.05%	0.3
Chironomid pupa	0		0		
Ceratopogonidae	0		0		
Empididae	0		0		
Pelecorhychidae	1	0.88%	0.0029	0.45%	0.1
Simulidae	6	5.31%	0.101	15.58%	0.1
Simulid pupa	0		0		
Tabanidae					
Tipulidee	1	0.88%	0.0001	0.02%	.1
TRICHOPTERA					
Brachycentridae	1	0.88%	0.0001	0.02%	0.1
Gloseosomatidar	0		0		
Helicopcychidae	0		0		
Hydropsychidae	1	0.88%	0.0055	0.85%	0.1
Lepidostomatidae	0		0		
Leptoceridm	0		0		
Limnephilidae	0		0		
Rhyacophiliiae	0		0		
COLEOPTERA	0		0		
Amphizoidae Adult	1	0.88%	0.0001	0.02%	0.1
Elmidw larva	0		0		
Elmidae adult	1	0.88%	0.0001	0.02%	0.1
Amphizoidae	1	0.88%	0.0001	0.02%	0.1
PLECOPTERA	0		0		
Nemouridae	0		0		
Perlidae	8	7.08%	0.1368	21.1%	0.4
Pteronarcyidae	0		0		
EPHEMEROPTERA	0		0		
Baetidae	8	7.08%	0.0007	0.11%	0.6
Ephemerellidae	6	5.31%	0.0182	2.81%	0.2
Heptageniidae	7	6.19%	0.0013	0.2%	0.5
Leptophlebiidae	0		0		
OLIGOCHAETA	36	30.97%	0.3015	46.5%	0.2
TURBELLARIA	0		0		
MOLLUSCA	0		0		
HYDRACARINA	0		0		
TERRESTRIALS	19	16.81%	0.0182	2.81%	0.5
LEPIDOPTERA	[illegible]	7.96%	0.0096	1.48%	0.
UNIDENTIFIED PARTS	3	2.66%	0.0116	1.79%	0.3
COTTIDAE	1	%	-	-	0.1

TABLE E.IO.

Diet analysis of 1 1 juvenile (100 mm < x < 250 mm FL) bull trout collected from the Tucannon River, August, 27, 1991. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCURREN.
DIPTERA					
Chironomidae	10	17.54%	0.0046	1.2%	0.4
Chironomid pupa	0		0		
Ceratopogonidae	0		0		
Empididae	0		0		
Pelecorhychidae	2	3.51%	0.004	1.04%	0.1
Simulidae	0		0		
Simulid pupa	0		0		
Tabanidae	0		0		
Tipulidae	0		0		
TRICHOPTERA					
Brachycentridae	1	1.75%	0.001	0.26%	0.1
Glossosomatidae	0		0		
Helicopsychidae	0		0		
Hydropsychidae	0		0		
Lepidostomatidae	0		0		
Leptoceridae	3		0.0008		0.1
Limnephilidae	2		0.0078		0.2
Rhyacophilidae	2		0.0002		.
COLEOPTERA	0		0		
Amphizoidae Adult		.75%	0.0028	.0.73%	0.1
Elmidae larva	0		0		
Elmidae adult	0		0		
Amphizoidae	1	1.75%	0		.
PLECOPTERA	0		0		
Nemouridae	1	1.75%	0.0024	0.63%	0.1
Perlidae	4	7.02%	0.0084	2.19%	0.4
Pteronarcyidae	0		0		
EPHEMEROPTERA	0		0		
Baetidae	6	10.53%	0.0117	3.05%	0.5
Ephemerellidae	3	5.26%	0.0026	0.68%	0.2
Heptageniidae	3	5.26%	0.0033	0.86%	0.3
Leptophlebiidae	0		0		
OLIGOCHAETA	2	. %	0.1143	29.78%	.
AMPHIBIAN	1	.75%	0.0497	12.95%	. 0.1
OSTRACODA	2	. %	0.0012	.0.31%	0.1
COLLEMBELLA	1	. .75%	0.0003	0.08%	,
TERRESTRIALS	7	12.28%	0.0347	9.04%	.
LEPIDOPTERA	2	. %	0.0538	14.02%	0.1
UNIDENTIFIED PARTS	2	. %	0.0109	2 .84%	.
COTTIDAE	1	1.75%	0.0693	1806%	0.1

TABLE E. 11.

Diet analysis of 10 juvenile (100 mm c x < 250 mm FL) steelhead trout collected from the Tucennon River, July 24, 1991. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCURREN.
DIPTERA					
Chironomidae	4	2.6%	0.0006	0.2%	0.3
Chironomid pupa	1	0.65%	0.0003	0.1%	0.1
Ceratopogonidae	3	1.95%	0.0001	0.03%	0.3
Empididae	3	1.95%	0.001	0.34%	0.2
Pelecorhychidae	5	3.25%	0.0048	1.61%	0.3
Simulidae	10	6.49%	0.002	0.67%	0.2
Simulid pupa	0		0		
Culoidae	1	0.66%	0.0001	0.03%	0.1
Tipulidae					
TRICHOPTERA					
Brachycentridae	0		0		
Gloseosomatidw	5	3.25%	0.0076	2.55%	0.2
Helicopeyohidas	0		0		
Hydropsychidae	2	1.3%	0.0011	0.37%	0.2
Lepidostomatidae	0		0		
Leptoceridae	3	1.95%	0.0001	0.03%	0.1
Limnephilidae	11	7.14%	0.0216	7.25%	0.4
Rhyacophilidae	1	0.65%	0.0001	0.03%	0.1
COLEOPTERA	0		0		
Curculionidae	1	0.65%	0.0001	0.03%	0.1
Elmidae larva	0		0		
Elmidae adult	0		0		
Amphizoidao	1	0.65%	0.0058	1.95%	0.1
PLECOPTERA	0		0		
Nemouridae	1	0.65%	0.0001	0.03%	0.1
Perlidae	8	5.19%	0.1635	54.85%	0.6
Pteronarcyidae	0		0		
EPHEMEROPTERA	0		0		
Baetidae	40	25.97%	0.0142	4.76%	0.7
Ephemerellidae	2	1.3%	0.0006	0.2%	0.1
Heptageniidae	21	13.64%	0.0098	3.29%	0.7
Leptophlebiidae	0		0		
OLIGOCHAETA	0		0		
TURBELLARIA	2	.3%	0.002	0.67%	0.1
MOLLUSCA	0		0		
HYDRACARINA	0		0		
TERRESTRIALS	9	5.84%	0.0269	9.02%	0.3
LEPIDOPTERA	13	.44%	0.0154	5.17%	
UNIDENTIFIED PARTS	7	4.55%	0.0203	0.91%	0.4
COTTIDAE	0		0		

TABLE E. 12.

Diet analysis of 10 juvenile (100 mm < x < 250 mm FL) steelhead trout collected from the Tucannon River, August 27, 1991. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCURREN.
DIPTERA					
Chironomidae	4	3.77%	0.0015	0.29%	0.3
Chironomid pupa	0		0		
Ceratopogonidae	0		0		
Empididae	0		0		
Pelecorhychidae	1	0.94%	0.002	0.38%	0.1
Simulidae	4	3.77%	0.0064	1.23%	0.3
Simulid pupa	0		0		
Culcidae	0		0		
Tipulidae	0		0		
TRICHOPTERA					
Brachycentridae	4	766.84%	0.0089	1.7%	0.3
Glossosomatidae	7	6.6%	0.0246	4.71%	0.2
Helicopsychidae	0		0		
Hydropsychidae	1	0.94%	0.027	5.17%	0.1
Lepidostomatidae	0		0		
Leptoceridae	3	2.83%	0.0047	0.9%	0.3
Limnephilidae	3	2.83%	0.0126	2.41%	0.1
Rhyacophilidae	1	0.94%	0.0041	0.78%	0.1
COLEOPTERA	0		0		
Hydrohilidae	1	0.94%	0.0022	0.42%	0.1
Elmidae larva	0		0		
Elmidae adult	0		0		
Amphizoidae	1	0.94%	0	0.%	0.1
PLECOPTERA					
Nemouridae	0		0		
Perlidae	10	9.43%	0.1967	37.60%	.
Pteronarcyidae	a		a		
EPHEMEROPTERA	0		0		
Baetidae	23	21.7%	0.0121	2.32%	0.6
Ephemerellidae	13	12.26%	0.0089	1.7%	0.2
Heptageniidae	4	3.77%	0.0046	0.88%	0.3
Leptophlebiidae	2	1.89%	0.0016	0.31%	0.1
OLIGOCHAETA	0		0		
TURBELLARIA	0		0		
MOLLUSCA	0		0		
HYDRACARINA	0		0		
TERRESTRIALS	17	16.04%.	0.0686.	13.13%	.
LEPIDOPTERA	5	4.72%	0.0539	10.32%	.
UNIDENTIFIED PARTS	1	0.94%	0.00'14	0.27%	0.1
COTTIDAE	1	191 .46%	0.0806	15.41%	.

Table E.13
Diet anslysis of 9 adult bull trout (250 mm < x) collected from Mill Creek on August 16, 1990.

FISH NUMBER	DATE OF COLLECTION	FORK LENGTH	SEX	STOMACH
1	8/16/90	270	F	empty
2	8/16/90	294	M	empty
3	8/16/90	287	M	empty
4	8/16/90	318	M	empty
5	8/16/90	364	M	empty
6	8/16/90	370	F	empty
7	8/16/90	480	F	empty
8	8/16/90	620	F	empty

Table E.14.

Diet analysis of 7 juvenile (100 < x < 250 mm FL) rainbow trout collected from Mill Creek, August, 1990. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCUR.
DIPTERA					
Chironomidae	9	4.33%	0.0035	1.68%	0.5
Chironomid pupa	7	3.37%	0.0013	0.62%	0.13
Chironomid adult	4	1.92%	0.0012	0.58%	0.13
Empididae	0		0		
Pelecorhychidae	2	0.96%	0.0031	1.49%	0.13
Simulidae	9	4.33%	0.007	3.36%	0.38
Simulid pupa	1	0.48%	0.0009	0.43%	0.13
Tabanidae	0		0		
Tipulidae	0		0		
TRICHOPTERA	0		0		
Brachycentridae	5	2.4%	0.0011	0.53%	0.25
Glossosomatidae	0		0		
Helicopsychidae	0		0		
Hydropsychidae	2	0.96%	0.004	1.92%	0.25
Lepidostomatidae	0		0		
Leptoceridae	0		0		
Limnephilidae	1	0.48%	0.0064	3.07%	0.13
Rhyacophilidae	3	1.44%	0.0012	0.58%	0.38
Hydrophilidae	0		0		
COLEOPTERA	0		0		
Hydrophilidae	0		0		
Elmidae larva	0		0		
Elmidae adult	0		0		
Spheridae adult	1	0.48%	0.0024	1.15%	0.13
PLECOPTERA	0		0		
Chloroperlidae	1	0.48%	0.0026	1.25%	0.13
Perlidae	5	2.4%	0.0139	6.67%	0.5
Pteronarcyidae	0		0		
EPHEMEROPTERA					
Baetidae	28	13.46%	0.007	3.36%	0.63
Ephemerellidae	2	0.96%	0.0034	1.63%	0.25
Heptageniidae	3	1.44%	0.0017	0.82%	0.25
Leptophlebiidae	0		0		
OLIGOCHAETA	1	0.48%	0.0005	0.24%	0.13
TURBELLARIA			0		
HYDRACARINA	0		0		
TERRESTRIALS	120	57.69%	0.1322	63.41%	1
LEPIDOPTERA	1	.48%	0.0077	3.69%	0.13
UNIDENTIFIED PARTS	3	1.44%	0.0074	3.55%	0.38
GASTROPODA	0'		0		
COTTIDAE	0		0		

Table E. 15.

Diet anslysis of 7 adult (250 < mm FL) rainbow trout collected from Mill Creek, August, 1990. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FRED. OF OCCUR.
DIP-I-ERA					
Chironomidae	2	3.57%	0.0024	0.26%	0.14
Chironomid pupa	0		0		
Chironomid adult	0		0		
Empididae	0		0		
Pelecorhychidae	0		0		
Simulidae	0		0		
Simulid pupa	2	3.57%	0.0011	0.12%	0.14
Tabanidae	0		0		
Tipulidae	0		0		
TRICHOPTERA	0		0		
Brachycentridae	0		0		
Glossosomatidae	1	1.79%	0.0036	0.39%	0.14
Helicopsychidae	0		0		
Hydropsychidae	0		0		
Lepidostomatidae	0		0		
Leptoceridae	0		0		
Limnephilidae	0		0		
Rhyaoophilidw	1	1.79%	0.0104	1.12%	0.14
Hydrophilidae	0		0		
COLEOPTERA	0		0		
Hydrophilidae	0		0		
Elmidae larva	0		0		
Elmidw adult	0		0		
Spheridae adult	0		0		
PLECOPTERA	0		0		
Chloroperlidae	0		0		
Perlidae	4	7.14%	0.1114	11.99%	0.29
Pteronarcyidae	0		0		
EPHEMEROPTERA					
Baetidae	3	5.36%	0.002	0.22%	0.43
Ephemerellidae	0		0		
Heptageniidae	1	1.79%	0.0001	0.01%	0.14
Leptophlebiidae	0		0		
OLIGOCHAETA	0		0		
TURBELLARIA	0		0		
HYDRACARINA	0		0		
TERRESTRIALS	39	69.64%	0.1239	1334%	0.86
LEPIDOPTERA	0		0		
UNIDENTIFIED PARTS	1	1.79%	0.0006	0.06%	0.14
GASTROPODA	1	1.79%	0.5404	58 . 10%	0.14
COTTIDAE	1	. %	0,1332	14.34%	0.14

Table E.16.

Diet anslysis of two adult and one juvenile bull trout collected from the Tucannon River in August 1990. The number and weight (g) of each organism found in stomach is reported.

ORGANISMS	FISH #1 = 273 mm		FISH # 2 = 254 mm		FISH # 3 = 152 mm	
DIPTERA	NUMBER	WEIGHT (g)	NUMBER	WEIGHT (g)	NUMBER	WEIGHT (g)
Chironomidae					EMPTY STOMACH	
Chironomid pupa						
Chironomid adult						
Empididae						
Pelecorhychidae						
Simulidae						
Simulid						
Tabanidae						
Tipulidae						
TRICHOPTERA						
Brachycentridae						
Glossosomatidae						
Helicopsychidae						
Hydropsychidae						
Lepidostomatidae						
Leptoceridae						
Rhyacophilid larve						
Rhyacophilidae						
COLEOPTERA						
Amphizoidae adult						
Elmidae larva						
Elmidae adult						
Gyrinidae adult						
PLECOPTERA						
Chloroperlidae						
Perlidae						
Pteronarcyidae						
EPHEMEROPTERA						
Baetidae						
Ephemerellidae						
Heptageniidae						
Leptophlebiidae						
OLIGOCHAETA						
TURBELLARIA						
HYDRACARINA						
TERRESTRIALS						
LEPIDOPTERA						
UNIDENTIFIED PARTS						
O. Mykiss	2	1.0969				
COTTIDAE			1	0.5492		

Table E.17.

Diet anslysis of 7 juvenile (250 > mm FL) steelhead trout collected from the Tucannon River, October, 1990. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FRED. OF OCCUR.
DIPTERA					
Chironomidw	0		0		
Chironomid pupa	0		0		
Chironomid adult	0		0		
Empidiiae	0		0		
Pelecorhychidae	0		0		
Simulidae	0		0		
Simulid pupa	0		0		
Tabanidae	0		0		
Tipulidae	0		0		
TRICHOPTERA	0		0		
Brachycentridao	0		0		
Glossosomatidae	0		0		
Helicopsychidae	0		0		
Hydropsychidae	11	13.92%	0.0173	7.47%	0.57
Lepidostomatidae	0		0		
Leptoceridas	0		0		
Limnephilidae	0		0		
Rhyaoophilidae	0		0		
Trichoptera pupa	0		0		
COLEOPTERA	0		0		
Amphizoidw adult	0		0		
Elmidae larva	0		0		
flmidas adult	0		0		
Gyrinidae adult	0		0		
PLECOPTERA	0		0		
Chloroperlidae	0				
Perlidae	0		0		
Pteronarcyidae	0		0		
EPHEMEROPTERA					
Baetidae	0		0		
Ephemerellidae	2	2.53%	0.0066	2.85%	0.14
Heptageniidae	0		0		
Leptophlebiidae	0		0		
OLIGOCHAETA	0		0		
TURBELLARIA	0		0		
HYDRACARINA	0				
TERRESTRIALS	65	82.28%	0.2065	89.12%	.7
LEPIDOPTERA	0		0		
UNIDENTIFIED PARTS	t	.27%	0.0013	0.56%	0.14
GASTROPODA	0		0		
COTTIDAE	0		0		

Table E.18. .

Diet analysis of 6 adult (250 < mm -FL) rainbow trout collected from the Tucannon River, October, 1990. The number and weight (g) of each organism found in each stomach is reported.

	COMBINED NUMBER	% BY #	COMBINED WEIGHT	% BY WT.	FREQ. OF OCCUR.
DIPTERA					
Chironomidae	1	2.22%	0.0003	0.02%	0.17
Chironomid pupa	0		0		
Chironomid adult	a		-		
Empididae	0		0		
Pelecorhychidae	0		0		
Simulidae	0		0		
Simulid pupa	0		0		
Tabanidae	0		0		
Tipulidae	0		0		
TRICHOPTERA	0		0		
Brachycentridae	6	13.33%	0.4929	27.6%	0.33
Glossosomatidae	16	35.56%	0.6165	34.52%	0.66
Helicopsychidae	0		0		
Hydropsychidae	2	4.44%	0.0063	0.35%	0.17
Lepidostomatidae	0		0		
Leptoceridae	0		0		
Limnephilidae	0		0		
Rhyacophilidae	0		0		
Trichoptera pupa	1	2.22%	0.006	0.34%	0.17
COLEOPTERA	0		0		
Amphizoidae adult	5	11.11%	0.0006	0.03%	0.17
Elmidae larva	0		0		
Elmidae adult	0		0		
Gyrinidae adult	1	2.22%	0.0009	0.05%	0.17
PLECOPTERA	0		0		
Chloroperlidae	0		0		
Perlidae	0		0		
Pteronarcyidae	0		0		
EPHEMEROPTERA					
Baetidae	0		0		
Ephemerellidae	0		0		
Heptageniidae	0		0		
Leptophlebiidae	0		0		
OLIGOCHAETA	0		0		
TURBELLARIA	0		0		
HYDRACARINA	0		0		
TERRESTRIALS	12	26.67%	0.0189	"1.06%	0.86
LEPIDOPTERA	0		0		
UNIDENTIFIED PARTS	0		0		
GASTROPODA	0		0		
COTTIDAE	1	2.22%	0.6437	36.04%	

TABLE E. 19.

Procedures and data used in the computation of the diet overlap (Cx) between bull trout and rainbow trout in Mill Creek, July, 1991.

ORGANISMS	BULL TROUT (Pxi)	(Pxi)2	RAINBOW TROUT (Pyi)	(Pyi)2	Pxi X Pyi
DIPTERA					
Chironomidw	0.0566	0.00309	0.0256	0.00066	0.00142
Chironornid pupa	0.0111	0.00012		0.	0.
Pelecorhychidae	0.0444	0.00197	0.0128	0.00016	0.00057
Simulidae	0.0111	0.00012		0.	0.
TRICHOPTERA					0.
Hydropsychidae		0.	0.0128	0.00016	0.
Glossosomatidae	0.0333	0.00111	0.0064	0.00004	0.00021
Limnephilidae		0.	0.0321	0.00103	-0.
Rhyacophilidae	0.0111	0.		0.	0.
COLEOPTERA					
Elmidae adult		0.	0.0004	0.00004	0.
Gyrinidae		0.	0.0064	0.00004	0.
Carabidae	0.0111	0.		0.	0.
PLECOPTERA					
Chloroperlidae	0.0111	0.00012			
Perlidae	0.1666	0.02421	0.0321	0.00103	
EPHEMEROPTERA					
Baetidae	0.3333	0.11109	0.2372	0.05626	0.07906
Ephemerellidae	0.0333	0.001 11	0.0256	0.00066	0.00085
Heptageniidae	0.0167	0.00446	0.0887	0.00787	0.00682
TURBELLARIA	0.0222	0.00049			
UNIDENTIFIED PARTS	0.0333	0.00111	0.0064	0.00004	0.00021
COTTIDAE	0.0111	0.00012			
TERRESTRIALS	0.0556	0.0030s	0.109	0.01188	0.00608’
LEPIDOPTERA	0.0222	0.00048	0.0128	0.00016	0.00028
GASTROPODA		0.	0.0064	0.00004	0.
TOTALS:		0.16271		0.08004	0.09469

$$CX = \frac{2 \times 0.09469}{0.5838 + 0.06869}$$

$$\boxed{Cx = 0.81}$$

TABLE E.20.
Procedures and data used in the computation of the diet overlap (Cx) between bull trout and rainbow trout in Mill Creek, August, 1991.

ORGANISMS	BULL TROUT (Pxi)	(Pxi)2	STEELHEAD TROUT (Pyi)	(Pyi)2	Pxi X Pyi
DIPTERA					
Chironomidae	0.0207	0.00043	0.0227	0.00052	0.00047
Empididae	0	0.	0.0025	0.00001	0.
Simulidae	0.0133	0.00019	0.0151	0.00023	0.00021
TRICHOPTERA					0.
Brachycentridae	0	0.	0.005	0.00003	0.
Glossosomatidae	0.0069	0.00005	0.0076	0.00006	0.00005
Limnephilidae	0	0.	0.0076	0.00006	0.
Rhyacophilidae	0	0.	0.002s	0.00001	0.
COLEOPTERA					
Elmidae adult	0	0.	0.0025	0.00001	0.
Hydrophilidae	0	0.	0.0101	0.0001	0 .
PLECOPTERA					
Nemouridae	0	0.	0.0302	0.00091	0.
Perlidae	0.0483	0.00233	0.0101	0.0001	0.00049
EPHEMEROPTERA					
Baetidae	0.7586	0.67647	0.1674	0.02802	0.12699
Ephemerellidae	0.0346	0.00119	0.0026	0.00001	0.00009
Heptageniidae	0.0207	0.00043	0.0277	0.00077	0.00057
UNIDENTIFIED PART6			0.005	0.00003	0.
COTTIDAE	0.0345	0.00119			
TERRESTRIALS	0.0483	0.00233	0.1687	0.02619	0.00767
LEPIDOPTERA	0.0133	0.00019	0.0262	0.00064	0.00036
HYDRACARINA	0	0.	0.0025	0.00001	0.
TOTALS:		0.66361		0.05666	0.13688

$$cx = \frac{2 \times 0.13688}{0.5838 + 0.05669}$$

$\boxed{Cx = 0.43}$

TABLE E.21.

Procedures and data 'used in the computation of the diet overlap (Cx), between bull trout and steelhead trout in the Wolf Fork, July, 1991.

ORGANISMS	BULL TROUT (Pyi)	(Pxi)2	STEELHEAD TROUT (Pxi)	(Pyi)2	Pxi X Pyi
DIPTERA					
Chironomidae	0.078 1	0.0061	0.1056	0.01 115	0.00825
Chironomid pupa	O.&l 66	0.00024	0.0141	0.0002	0.00022
Pelecorhychidae			0.007	0.00005	0.
Empididw		0.		0.	0.
Simulidae pupa		0.	0.007	0.00005	0.
TRICHOPTERA					0.
Brachycentridae	0.0156	0.00024	0.007	0.00005	0.00011
Gloeeoeomatidae	0.0313	0.00098	0.0423	0.0017s	0.00132
Hydropsychidae	0.171s	0.02966	0.0986	0.00972	0.01695
Leptoceridae	0.0158	0.00024	0.0211	0.00046	0.00033
Limnephilidae		0.	0.0141	0.0002	0.
Rhyacophilidae	0.0313	0.00098	0.0493	0.00243	0.00154
COLEOPTERA					
Curculionidae		0.	0.007	0.00005	0.
PLECOPTERA		0 .		0.	0.
Chloroperlidae		0.	0.007	0.00005	0.
Perlidae	0.1846	0.03404	0.0643	0.00413	0.01186
EPHEMEROPTERA					
Baetidae	0.1406	(0.01977	0.0563	0.00317	0.00792
Ephemerellidae	0.1683	0.02443	0.2142	0.04588	0.03348
Heptageniidae	0.0469	0.0022	0.0634	0.00402	0.00297
OLIGOCHAETA	0.0141	0.0002'	0.0141	0.0002	0.0002
UNIDENTIFIED PARTS	0.0489	0.0022	0.0423	0.0017s	0.00198
COTTIDAE		0 .			
TERRESTRIALS	0.0313	0.00098	0.0845	0.00714	0.00204
LEPIDOPTERA	0.0166	0.00024	0.0141	0.0002	0.00022
MOLLUSCA		0.	0.007	0.00005	0.
TOTALS:		0.1224		0.09271	0.09

$$c \quad x \; \frac{2 \times 0.09}{0.1224 + 0.09685}$$

$$\boxed{Cx = 0.84}$$

TABLE E.22.

Procedures and data used in the computation of the diet overlap (Cx), between bull trout and steelhead trout in the Wolf Fork, August, 1991

ORGANISMS	BULL TROUT (Pxi)	(Pxi)2	STEELHEAD TROUT (Pyi)	(Pyi)2	Pxi X Pyi
DIPTERA					
Chironomidae	0.1939	0.0376	0.0596	0.00355	0.01156
Chironomid pupa	0.0061	0.00004			0.
Pelecorhychidae	0.0182	0.00033	0.0043	0.00002	0.00008
Empidae	0.0061	0.00004			0.
Stratiiomyidae.	0.0061	0.00004			0.
TRICHOPTERA					
Brachycentridae			0.0213	0.00045	0.
Glossosomatidae	0.0121	0.00015			-0.
Hydropsychidae	0.0121	0.00016	0.0383,	0.00147	0.00046
Leptoceridae	0.0303	0.00092,	0.0213	0.00045	0.00066
Rhyacophilidae	0.0242	0.00059	0.0043	0.00002	0.0001
COLEOPTERA					
Curculionidae			0.0043	0.00002	0
Elmidae adult	0.0121.	0.00016			0
Hydrophilidae	0.0121	0.00015			0.
PLECOPTERA					
Chloroperlidae	0.0061	0.00004	0.0043	0.00002	0.00003
Perlidae	0.0727	0.00529	0.034	0.00116	0.00247
Pteronarcyidae			0.0043	0.00002	0.
EPHEMEROPTERA					
Baetidae	0.2727	8.07437	0.3194	0.10202	0.0871
Ephemerellidae	0.0711	0.00528	0.1234	0.01523	0.00897
Heptageniidae	0.0909	0.00826	0.0426	0.00181	0.00387
OLIGOCHAETA	0.0061	0.00004			0.
UNIDENTIFIED PARTS	0.0061	0.00004			0
COTTIDAE	0.0061	0.00004			0.
TERRESTRIALS	0.1152	0.01327	0.2723	0.07415	0.03137
HYDRACARINA	0.0061	0.00004			0
TOTALS:		0.14879		0.20038	0.14868

$$Cx = \frac{2 \times 0.14694}{0.14682 + 0.20257}$$

$$\boxed{Cx = 0.84}$$

TABLE E. 23.

Procedures and data used in the computation Of the diet overlap (Cx), between bull trout and steelhead trout in the Tucannon River, July, 1991.

ORGANISMS	BULL TROUT (Pxi)	(Pxi)2	STEELHEAD TROUT (Pyi)	(Pyi)2	Pxi X Pyi
DIPTERA					
Chironomidae	0.0354	0.00125	0.026	0.00068	0.00092
Chironomid pupa			0.0065	0.00004	0.
Ceratopogonidae			0.026	0.00068	0.
Empidae			0.0195	0.00038	0.
Pelecorhychidae	0.0088	0.00008	0.0326	0.00106	0.00029
Simulidae	0.0531	0.00282	0.0584	0.00341	0.0031
Tipulidae	0.0088	0.00008			0.
TRICHOPTERA					
Brachycentridae	0.0088	0.00008		0.	0.
Glossosomatidae			0.0325	0.00106	0.
Hydropsychidae	0.0083	0.00008	0.013	0.00017	0.00011
Leptoceridae		0.	0.0136	0.00038	0.
Limnephilidae		0.	0.0714	0.0051	0.
Rhyacophilidae		0.	0.0065	0.00004	0.
COLEOPTERA					
Elmidae adult	0.0088	0.00008		0.	0.
Curculionidae			0.0065	0.00004	
Amphizoidae adult	0.0088	0.00008			0.
Amphizoidae pupa	0.0088	0.00008	0.013	0.00017	0.00011
PLECOPTERA					
Nemouridae		0.	0.0065	0.00004	0.
Perlidae	0.0708	0.00501	0.0519	0.00288	0.00367
EPHEMEROPTERA					
Baetidae	0.0708	0.00501	0.2587	0.06744	0.01833
Ephemerellidae	0.0631	0.00282	0.013	0.00017	0.00060
Heptageniidae	0.0813	0.00383	0.1354	0.0188	0.00844
OLIGOCHAETA	0.3037	0.0969 1			0.
UNIDENTIFIED PARTS	0.0266	0.0007	0.0455	0.00207	0.00121
COTTIDAE	0.0088	0.00008		0.	0.
TERRESTRIALS	0.1681	0.02828	0.0584	0.00341	0.00982
LEPIDOPTERA	0.0796	0.00634	0.0048	0.00421	0.00517
TOTALS:		0.16268		0.11185	0.05192

$$cx = \frac{2 \times 0.05193}{0.16268 + 0.11201}$$

Cx =	0.38

TAME E.24.

Procedures and data used in the computation of the diet overlap (Cx), between bull trout and steelhead trout in the Tucannon River, August, 1991.

ORGANISMS	BULL TROUT (Pxi)	(Pxi)2	STEELHEAD TROUT (Pyi)	(Pyi)2	Pxi X Pyi
DIPTERA					
Chironomidae	0.1786	0.0319	0.035	0.00~3	0.00643
Pelecorhychidae	0.0357	0.00127	0.003	0.00008	0.00032
Simulidae			0.036	0.0013	0.
TRICHOPTERA					
Brachycentridae	0.0173	0.00032	0.035	0.0013	0.00064
Glossosomatidae			0.0631	0.00338	0.
Hydropsychidae			0.009	0.00008	0.
Leptoceridae	0.0536	0.00287	0.027	0.00073	0.00145
Limnephilidae	0.0357	0.00127	0,027	0.00073	0.00096
Rhyacophilidae	0.0357	6.00127	0.009	0.00008	0.60032
COLEOPTERA					
Hydrophilidae	0.0173	0.00032	0.003	0.00008	0.00016
PLECOPTERA					
Nemouridae	0.0179	0.00032			0.
Perlidae	0.0714	0.0061	0.0901	0.00812	0.00643
EPHEMEROPTERA					
Baetidae	0.1071	0.01147'	0.2072	0.04283	0.02219
Ephemerellidae	0.0536	0.00287	0.1171	0.01371	0.00628
Heptageniidae	0.0536	0.00287	0.036	0.0013	0.00133
Leptophlebiidae			0.018	0.00032	0
OLIGOCHAETA	0.0357	0.00127			0.
UNIDENTIFIED PARTS	0.2	0.04			0
COTTIDAE	0.6179	0.00032	0.009	0.00008	0.
TERRESTRIALS	0.126	0.01583	0.1632	0.02347	0.01316
LEPIDOPTERA	0.0357	0.00127	0.045	0.00203	0.00161
DSTRACOOA	0.0367	0.00127			0.
AMPHIBIAN	0.0178	0.00032			0
TOTALS:		0.12186		0.10161	0.05788

$$Cx = \frac{2 \times 0.06788}{0.12196 + 0.10169}$$

$$\boxed{Cx = 0.61}$$

TABLE E. 24. (CONT.)

Procedures and data used in the computation of the diet overlap (Cx) between bull trout and spring chinook salmon in the Tucannon River. The bull trout diet information is the mean value of the July and August 1991 sampling. The spring chinook salmon diet information is for the time period of July through September, 1988 (Bugert 1990)

ORGANISMS	BULL TROUT (Pxi)	(Pxi)2	SPRING CHINOOK SALMON (Pyi)	(Pyi)2	Pxi X Pyi
DIPTERA					
Chironomidae	0.107	0.01145	0.049	0.0024	0.06624
Chironomid pups			0.71	0.5041	
Pelecorhychidae	0.0223	0.0005			
Simulidae	0.0044	0.00002	0.036	0.0013	0.00016
Tipulidw	0.6044	0.00002			
TRICHOPTERA					
Brachycentridae	0.0134	0.00018			
Glossosomatidae			0.007	0.00005	
Glossosomatidae pupa			0.01	0.0001	
Hydropsychidae	0.0044	0.00002			
Leptoceridae	0.0268	0.00072			
Limnephilidae	0.0173	0.00032	0.01	0.0001	0.00018
Rhyacophilidae	0.0173	0.00032			
COLEOPTERA					
Hydrophilidae	0.009	0.00008			
Elmidae adult	0.0044	0.00002	0.104	0.01082	
Elmidae pupa			0.048	0.00212	
Amphizoidae adult	0.0044	0.00002			
Amphizoidae pupa	0.0044	0.00002			
PLECOPTERA					
Chloroperlidae			0.014	0.0002	
Nemouridae	0.003	0.00008			
Perlidae	0.0711	0.00506	0.086	0.00723	0.00604
EPHEMEROPTERA					
Baetidae	0.033	0.00792	0.057	0.00325	0.00507
Ephemerellidae	0.0634	0.00285	0.192	0.03586	0.01025
Heptageniidae	0.0578	0.00334			
OLIGOCHAETA	0.1727	0.02983	0.007	0.00005	
UNIDENTIFIED PARTS	0.023	0.00053			
COTTIDAE	0.0134	0.00018			
TERRESTRIALS	0.0803	0.00815			
LEPIDOPTERA	0.0677	0.00333			
OSTRACODA	0.0179	0.00032			
AMPHIBIAN	0.009	0.00008			
TOTALS:		0.07535		0.56856	0.02695

$$Cx = \frac{2 \times 0.02585}{0.07535 + 0.5868}$$

$$\boxed{cx = 0.08}$$

APPENDIX F

FISH MOVEMENT AND MIGRATION

Table F.1.

Bull trout movement and migration information collected in the Tucannon River, 1990 and 1991.

CAPTURE DATE	TAG #	SEX	FORK LENGTH (CM)	CAPTURE LOCATION	RELEASE LOCATION	RECAPTURE LOCATION AND DATE OF RECAP.
3-June-90	00047	?	37	Lower Trap	Above Trap	@ Little Tucannon R. (Rk 74.4) 5 July, 1990
4-June-90	00041	?	46	Lower Trap	Above Trap	@ Little Tucannon R.(Rk 74.6) 14 July, 1990
31-Dec-90	000163	M	34	Lower Trap	Above Trap	
3-Jan-91	000162	M	34	Lower Trap	Above Trap	
4-Jan-91	000161	t	34	Upper Trap	Below Trap	
10-Jan-91	000160	1	32	Lower Trap	Above Trap	
10-Jan-91	000157	?	38	Lower Trap	Above Trap	
22-Feb-91	none	F	53	Dead @ Trap		
24-May-91	000155	F	56	Lower Trap	Above Trap	
30-May-91	000211	?	64	Lower Trap	Above Trap	
3-June-91	000212	?	50	Lower Trap	Above Trap	Dead at the trap. 10 June, 1991
3-June-91	000213	?	59	Lower Trap	Above Trap	
3-June-91	000214	?	53	Lower Trap	Above Trap	
3-June-91	000215	?	60	Lower Trap	Above Trap	1 Km up Panjab (Rk 77.5) 30 June, 1991
5-June-91	000217	?	58	Lower Trap	Above Trap	
8-June-91	000216	M	51	Lower Trap	Above Trap	
10-June-91	000218	?	51	Lower Trap	Above Trap	
11-June-91	000483	F	64	Lower Trap	Above Trap	Seen @ Bear Creek (Rk 90) 6 Sept, 1991
12-June-91	000484	?	36	Lower Trap	Above Trap	
28-Nov-91	000485	M	43	Hatchery Effluent	Above Trap	

APPENDIX G

BULL TROUT AGE DETERMINATION, WITH AGE REPRODUCIBILITY INDICES, METHODS, AND RESULTS

Authors have stated a need for comparing the precision or reproducibility of age determination (Chang 1982; Beamish and Fournier 1981). One of the most common techniques to assess the precision of fish age estimated from scale readings is to compare the percentages of determination of age which are agreed upon by several readers (Kennedy 1970). However, this technique has a disadvantage because it fails to take into consideration the range of fish year-class available to the fishery. For example, if 90% of age determinations between two readers agree within 1 year for a species that is harvested from a narrow age range, overharvest of a vulnerable age may lead to a collapse of the population. However, if this mistake is made on a long-lived species, the precision may not be as critical.

The use of an index that is not independent of age would provide a better estimate of precision than the percent agreement technique (Beamish and Foumier 198 1) . The authors caution the reader about precision, "the word precision is used to describe the reproducibility of age determinations. It *does not imply that the age estimates are accurate and only relates to the consistency among determinations" (Beamish and Foumier 1981).

We have applied Beamish and Fournier's (1981) method which is based on the assumption that the range of fish year-class available to the fishery increases in proportion to the average age of fish in the fishery . Or, in other words, that the standard deviation is proportional to the mean. The formula suggested by Beamish and Fournier (1981) determines an average percent error (APE) in aging the *jth* fish, and is given below:

$$APE = \frac{1}{R} \sum_{i=1}^{R} \frac{|X_{ij} - X_j|}{X_j}$$

where: R = the number of times the fish was aged;
X_{ij} = the *ith* age determined for the *jth* fish; and
X_j = the average age calculated for the *jth* fish.

The index (APE) can be used to compare determinations or readers. The set of determinations for a particular species with a smaller index is more precise than a larger index; greater precision is achieved as percent error is minimized.

The index of average error (IAE) is used to determine the error a reader has for a species and is given below:

$$IAE = \frac{1}{N} \sum_{j=1}^{N} \left[\frac{1}{R} \sum_{i=1}^{R} \frac{|X_{ij} - X_j|}{X_j} \right]$$

Where: N = the number of fish aged.

The set of determinations for a particular species with a smaller index is more precise. Greater precision is achieved as percent error is minimized.

Chang (1982) suggests the use of a coefficient of variation (V) for testing the reproducibility of aging between readers or for an individual reader comparing different streams. The coefficient of variation is the standard deviation as a fraction of the mean expressed as a percentage and may be obtained by replacing the average absolute deviation from the arithmetic mean age in the above equation with the standard deviation.

The formula for calculating the coefficient of variation is:

$$V = \frac{\left(\frac{\sum (X_{ij} - X_j)^2}{R(R-1)} \right)^{1/2}}{X_j}$$

where: X_{ij} = the ith age determined of the jth fish;
X_j = the average age calculated for the jth fish; and
R = the number of times the fish was aged.

The percent error contributed by each observation to the average age-class may be estimated by an index of precision (D), which is V divided by $\sqrt{R}$ (Elliott 1977; Sokal and Rohlf 1969).

The advantages of the average percent error index (APE) in determining the reproducibility of age determination is shared by the coefficients of variation (V) and the index of precision (V). These indices agree closely, particularly between APE and D. Because the coefficients of variation and the index of precision are indices which incorportate the averaged year-class of fish, they are free from the disadvantage of a percent agreement technique (Chang 1982).

Chang (1962) argues that there are additional benefits in using the coefficient of variation and the index of precision in the examination of reproducibility of age determination. First, variance is a bettetr estimator than absolute difference as it is an unbiased and consistent estimator, the mean and variance of which converge as sample size increases; the coefficient of variation for all practical purposes shares this property (Simpson et al 1960). Second, the index of precision (D) can be used to show the percent error contributed by each observation to the averaged age determination for the *jth* fish; if one multiplies the index of precision (D) by the averaged age for the *jth* fish, the result is the error in age determination made for each observation.

After determining the index of precision (D) for aging technique?, a one-way analysis of variance (ANOVA) was calculated to determine if the index was similar between streams. This allowed for interstream comparisons of age and growth based on the aging technique employed. If the index of precision between streams had been significantly different ($p < .05$) ligitimate interstream comparisons could not have been made.

Validation of any of the otolith samples waa not possible, 8s we know of no known age bull trout in any of these streams. However, until their fifth year of age, bull trout otoliths exibit very clear and distinct annular marks making age determination possible. To compare the otolith age analysis we consutructed a length/frequency histogram of all bull trout collected during the study to corroborate the otolith age with.

Constructing a length/frequency histogram that yields accurate cohorts is dependent upon equal reqruitment into the population. This means that the fish must have a seasonal reproductive cycle so that recruitment to the population occurs at intervals separated by approximately one year. All the fish born at approximately the same time form a cohort. Each cohort recruited in a given year has a one year growth idvantage over the next cohort to be recruited. Cohort3 form distinct modes in the size frequency distribution of the population and recognizable peaks in the distribution of sizes can be seen (Nielsen and Johnson 1983). This method provides uniform modes in the distribution of bull trout until their fourth year of growth. This is due to faster growing and stower growing flbh obscuring the modes of the graph. Also bull trout mature at age 4 (Skeesick 1989) and begin to show different rates of growth for males and females, however through age 4 this method provides valuable information because it provides an independent method of corroborating an ageing Scheme that is based on calcareous structures (Wooton 1990).

The following tables report the age for'each of the three readings, the fish fork lenght (mm), date of capture, sex, and the average percent error

The following. tables report the age for each of the three readings, the fish fork lenght (mm), date Of capture, sex, and the average percent error between readings, coefficient of variation, and the index of precision. The aging of bull trout collected from Mill Creek resulted in agreement between alll three readings for age 2 + , and age 7 +, while there was atleast one sat of readings for fish aged 3+ through 6+ that waa dissimilair (Table G.1.). The aginf of bull trout collected from the Wolf Fork resulted in agreement between all three readings for no age class, there was atleast one dissimiliar reading for every age class (Table G.2.). The aging of bull trout collected from the Tucannon River resulted in agreement between all three readings 0 + through 3 + , while there, was atleast one set of r eadings for fish aged 4 + through 6 + that was dissimiliar (Table G.3.).

A one-way analysis of variance (ANOVA, $\alpha = 0.01$) was p&formed on the degree of precision indice, to determine if the aging results varied significantly between streams. If the age had varied significantly between streams we would not have been able to 'make inter-stream comparisons of age-specific growth, diet, condition, habitat preference, maturity, and length at age.

Table G.4. shows the values used in the ANOVA, degrees of freedom, within and between group variance, critical values, and the observed F value for the degree of precision of age reproducibility for age determination.

Table G.1. Age analysis of bull trout collected from **Mill** Creek, 1990 and 1991

Otoliths collected from bull trout in Mill Creek were read 3 times independently. Average percent error, coefficient'of variation (V) and the index of precision (D) were determined for all otoliiha read to determine reproducibility between readings and streams.

FISH #	READING # 1st	2nd	3rd	FORK LN. (mm)	CAPTURE DATE	SEX	APE	V	D
1	2	2	2	135	29-Aug-91	-	0.00	0.00	0.00
2	2	2	2	166	29-Aug-91	-	0.00	0.00	0.00
3	3	3	3	199	13-Aug-90	F	0.00	0.00	0.00
4	2	2	2	201	29-Aug-91	-	0.00	0.00	0.00
5	3	3	3	211	13-Aug-90	M	0.00	0.00	0.00
6	3	3	3	220	29-Aug-91	-	0.00	0.04	0.00
7	2	2	2	226	29-Aug-91	-	0.00	0.00	0.00
8	3	3	3	240	13-Aug-90	M	0.00	0.00	0.00
9	4	3	3	240	13-Aug-91	-	0.13	0.16	0.09
10	4	5	5	260	17-Aug-90	F	0.09	0.12	0.07
11	3	3	3	267	17-Aug-90	F	0.00	0.00	0.00
12	3	3	3	270	15-Aug-90	F	0.00	0.00	0.00
13	6	5	5	349	17-Aug-90	F	0.08	0.10	6.06
14	4	4	5	360	15-Aug-90	F	0.12	0.16	0.08
15	4	4	4	368	17-Aug-90	F	0.00	0.00	0.00
16	4	4	4'	368	17-Aug-90	M	0.00	0.00	0.00
17	3	3	3	381	17-Aug-90	M	0.00	0.00	0.00
18	4	4	4	394	17-Aug-90	M	0.00	0.00	0.00
19	7	7	7	500	15-Aug-90	M	0.00	0.00	0.00
20	7	7	7	559	17-Aug-90	M	0.00	0.00	0.00
21	5	6	6	600	16-Aug-90	M	0.08	0.10	0.06

Table G.2. Age analysis of bull trout collected from the Wolf Fork, 1990 and 1991

Otoliths collected from bull trout in the Wolf Fork were read 3 times independently. Average percent error, coefficient of variation (V) and the index of precision (D) were determined for all otoliths read to determine reproducibility between readings and streams.

	READING #			FORK	CAPTURE				
FISH #	1st	2nd	3rd	ENGTH (mn	DATE	SEX	APE	V	D
1	2	2	2	124	28-Aug-91	-	0.00	1.00	0.00
2	2	2	2	154	28-Aug-91	-	0.00		0.00
3,	2	2	2	160	28-Aug-91	-	0.00		
4	2	2	2	160	28-Aug-91	-	0.00		
5	2	2	2	185	28-Aug-91	-	0.00	0.00	0.00
6	3	3	'3	105	29-Aug-91	-	0.00	0.00	0.00
7	3	2	2	165	28-Aug-91	-	0.19	0.23	0.13
8	2:	2	2	171	28-Aug-91	-	0.00	0.00	0.00
9	3	3		17s	28-Aug-91	-	0.21	0.25	0.15
fp	2	1	1	186	28-Aug-91	-	0.00	0.00	0.00
11	4	4	4	250	17-Jun-91	F	0.00	0.00	0.00
12	4	4	4	449	24-Aug-91	-	0.00	0.00	0.00
13	5	5	4	470	3-Jul-90	F	0.00	0.00	0.00

Table G.3. Age analysis of bull trout collected from the Tucannon River, 1 and 1991

Otoliths collected from bull trout in the Tucannon River were read 3 times independently. Average percent error, coefficient of variation (V) and the index of precision (D) were determined for al ototiis read to determine reproducibility between readings and streams.

	READING #			FORK	CAPTURE				
FISH #	1st	2nd	3rd	ENGTH (m	DATE	SEX	APE	V	D
1	0	0	0	46	1-Jul-90	-	0.00	0.00	0.00
2	1	1	1	73	1-Jul-90	-	0.00	0.00	0.00
3	1	1	1	76	1-Jul-90	-	0.00	0.00	0.00
4	1	1	1	85	1-Jul-90	-	0.00	0.00	0.00
5	1	1	1	86	1-Jul-90	-	0.00	0.00	0.00
6	1	1	1	91	1-Jul-90	-	0.00	0.00	0.00
7	1	1	1	95	1-Jul-90	-	0.00	0.00	0.00
8	1	1		107	1-Jul-90	-	0.00	0.00	0.00
9	2	2	3	120	27-Aug-91	-	0.00	0.00	0.00
10	2	2	2	125	27-Aug-91	-	0.00	0.00	0.00
11	2	2	2	135	27-Aug-91	-	0.00	0.00	0.00
12	2	2	2	150	2-Aug-90	-	0.00	0.00	0.00"
13	3	3	3	168	27-Aug-91	-	0.00	0.00	0.00
14	3	3		185	27-Aug-91	-	0.00	0:00	0.00.
15	3	3	3	189	27-Aug-91	M	0.00	0.00	0.00
16	3	3	3	202	2-Oct-91	M	0.00	0.00	0.00
17	3	3	3	202	2-Oct-91	M	0.00	0.00	0.00
18	3	3	3	203	2-Aug-90	-	0.00	0.00	0.00
19	4	4	4	220	1-Feb-90	F	0.00	0.00	0.00
20	3	3	3	225	10-Jun-91	F	0.00	0.00	0.00
21	4	3	4	230	2-Oct-91	M	0.12	0.15	0.09
22	4	4	4	242	9-Jun-91	F	0.00	0.00	0.00
23	4	4	4	250	9-Jun-91	F	0.00	0.00	0.00
24	4	4	4	250	17-Jun-91	M	0.00	0.00	0.00
25	4	4	4	252	8-Jun-91	M	0.00	0.00	0.00
26	4	4	4	255	9-Jun-91	-	0.00	0.00	0.00
27	4	4	4	280	2-Oct-91	-	0.00	0.00	0.00
28	5	5	5	300	9-Jun-91	F	0.00	0.00	0.00
29	5	4	4	325	3-Jun-91	F	0.12	0.15	0.08
30	4	4	4	332	9-Jun-91	F	0.00	0.00	0.00
31	6	5	6	335	2-Jun-91	F	0.08	0.10	0.06
32	4	4	4	350	9-Jun-91	-	0.00	0.00	0.00
33	4	5	4	350	10-Jun-91	M	0.12	0.15	0.08
34	5	5	5	352	2-Jun-91	M	0.00	0.00	0.00
35	5	4	5	373	27-Aug-91	-	0.09	0.12	0.07
36	4	4	4	380	1-Jun-91	M	0.00	0.00	0.00
37	5	5	4	380	2-Jun-91	F	0.09	0.12	0.07
38	4	4	4	402	3-Jun-91	-	0.00	0.00	0.00
39	5	5	5	410	10-Jun-90		0.00	0.00	0.00
40	5	5	5	430	9-Jun-91	F	0.00	0.00	0.00
41	5	5	5	475	4-Jul-91	M	0.00	0.00	0.00
42	5	5	5	480	1-Jun-90	F	0.00	0.00	0.00
43	5	5	5	510	10-Jun-90		0.00	0.00	0.00
44	5	6	6	565	4-Jul-91	F	0.08	0.10	0.06

Table 6.4.

One way **analysis** of **variance calculated** for the **degree** of **precision of age reproducibility (D)** for **bull trout collected** from **each of the study streams, 1990.**

Tucannclill Cre/olf Fork

Fish #	(D)	(D)	(D)
1	0	0	0
	0	0	0
3	0	0	0
4	0	0 '	0
5	0	0	0
6	0	0	0
7	0	0	0.13
8	0	0	0
9	0	0.09	0.15
10	0	0.07	0
11	0	0	0
12	0	0	0
13	0.09	0.06	0
14	0	0.08	
15	0	0	
16	0	0	
17	0	0	
18	0	0	
19	0	0	
20	0	0	
21	0.08	0.06	
22	0		
23	0.06		
24	0		
25	0.08		
26	0		
27	0.07		
26	0		
29	0.07		
30	0		
31	0		
32	0		
33	0		
34	0		
35	0		
36	0.06		

Ho: u1 = u2 = u3

Assume: variance is homogeneous, score distribution is normal, and the subjects are randomely and independently sampled.

B = 0.05

If Fobs c 3.12, do not reject Ho, at 0.05

If Fobs < 4.8, fo not reject Ho at 0.01

	df	ss	MS	F
etwee	2	0.0026	0.0013	1.182
within	75	0.0813	0.0011	
total	77	0.0838		

critical values: (df = 2,75 0.05 = 3.12
0.01 = 4.9

APPENDIX H

LENGTH AND WEIGHT OF EACH BULL TROUT USED IN CONSTRUCTING GROWTH CURVES

TABLE H.l.
Bull trout length-weight data collected from each of the study streams used to construct growth curves.

MILLCREEK

LENGTH (mm)	WEIGHT (g)
61	2.4
62	2.1
63	3.4
93	9.5
97	9
98	9
103	11.7
104	11
105	11.6
106	11.2
107	12.3
108	11.5
109	12.5
110	12.5
111	13.8
112	14.5
113	14
115	14.8
117	16
118	16.1
119	16.5
120	17.7
123	19
124	18.7
125	18.5
126	20.5
128	19
129	18.9
130	20
132	20
144	29
151	39.5
153	33.5
154	40
155	37.9
158	38
161	45.5
162	40.7
163	46.1
164	42.2
166	41.5
168	60
169	54.9
170	50
171	49
173	54

WOLF FORK

LENGTH (mm)	WEIGHT (g)
60	2.2
75	4.1
79	4.5
88	6.8
89	7.9
96	9.8
97	8.9
101	10
102	11
103	14.9
106	12
108	18
110	12.7
124	21.7
130	25
138	28.7
140	27.7
147	34.8
148	28.9
152	32.5
157	42.1
168	50
195	88.6
244	212.8
283	204.2
294	350

TUCANNON R.

LENGTH (mm)	WEIGHT (g)
66	2.9
69	3.6
75	4.5
76	3.8
77	4.5
78	3.9
81	5.5
84	5.3
85	5.5
86	6.1
87	6.5
90	7.1
91	7
92	7.2
93	7.3
96	9.6
98	a.3
106	12
110	14.7
116	15.6
119	17.7
120	16.9
124	18
128	21.4
131	22.3
133	22.9
140	28.4
141	41.2
147	34.3
148	35.1
149	33.6
150	40.3
154	48.2
155	37.2
157	38.5
167	49.5
170	58.6
181	68.1
182	55.1
225	134.3
234	153.1
263	215.3
299	295

TABLE H.1. (Cont.)

MILL CREEK

LENGTH (mm)	WEIGHT (g)
179	59.5
180	70.1
183	71
186	75.4
187	73.5
200	86
201	98
207	95
211	119.4
214	119
235	147
256	171
282	254
293	317.5

APPENDIX I

TEMPORAL AND SPATIAL BULL TROUT REDD DISTRIBUTION IN EACH OF THE STUDY STREAMS, 1990 AND 1991.

SPRING CHINOOK SALMON REDD DISTRIBUTION IN THE TUCANNON RIVER, 1991 AND SEVEN YEAR AVERAGE.

TABLE I.1.
Temporal and spatial distribution of bull trout redds in each of the study streams (--- indicates that the reach of the river was not surveyed).

MILL CREEK, 1991

SURVEY DATE:	9/9	9/17	9/25	10/7	1029
LANDMARK (River kilometer)					
Start of survey (Rk 31.0)					
	3	2'	3	2	---
Bull Creek (Rk 30.4)					
	5	2	5	2	
Deadman Creek (Rk 29.8)					
	1	8	4	4	
No. Fork Mill Cr. (Rk 26.1)					
	0	0	0	0	11
Electro. site # 10					
TOTAL # OF REDDS	9	12	12	8	11

WOLF FORK, 1991

SURVEY DATE:	9/4	9/12	9/21	10/3	10/10
LANDMARK (River kilometer)					
Survey start (Rk 19.0)					
	6	7	5	2	0
Electro. site # 1 (Rk 17.0)					
	6	4	3	9	1
Newby's residence (Rk 16.1)					
	2	7	0	2	2
Electro. site # 6 (Rk)					
	0	0	0	0	1
Creek crossing below Newby's (Rk)					
TOTAL # OF REDDS	14	18	8	13	4

TUCANNON RIVER, 1991

SURVEY DATE:	9/6	9/13	9/23	10/4	10/11
LANDMARK (River kilometer)					
Start of survey (Rk 88.0)					
	0	3	8	0	---
Bear Creek (Rk 86.5)					
	7	8	6	0	
Electro. site # 3 (Rk 84.6)					
	0	2	2	1	0
Tin-man Camp (Rk 84.0)					
	0	3	6	1	0
Ruchert's Camp (83.3)					
	0	0	0	2	9
Sheep creek (Rk 80.9)					
TOTAL # OF REDDS	[illegible]	16	22	4	9

TABLE 1.1.
Temporal and spatial distribution of bull trout redds in each of the study streams (--- indicates that the reach of the river was not surveyed).

MILL CREEK, 1990

SURVEY DATE	9/20	9/27	10/9
'LANDMARK (River kilometer)			
Start of survey (Rk 31.0)			

Bull Creek (Rk 30.4)			
	28	9	11
Deadman Creek (Rk 29.81			
	3	5	7
No. Fork Mill Cr. (Rk 26.1)			
	1	0	0
Electro. site # 10			
TOTAL # Of REDDS	3 2	16	18

WOLF FORK, 1990

SURVEY DATE:	9/5	9/11	9/18	9/25	10/3	10/8
LANDMARK (River kilometer)						
Survey start (Rk 19.0)						
	3	3	4	5	3	0
Electro. site # 1 (Rk 17.0)						
	6	7	3	3	1	0
Newby's residence (Rk 16.1)						
	0	1	1	4	4	1
Electro. site # 6 (Rk)						
Creek crossing below Newby's (Rk)						
TOTAL # OF REDDS	9	11	8	12	8	1

TUCANNON RIVER, 1990

SURVEYDATE:	9/19	9/26	10/4	10/11	10126	11/08
LANDMARK (River kilometer)						
start of survey (Rk 88.0)						
				---	--	
Bear Creek (Rk 86.6)						
				---		21
Electro. site # 3 (Rk 84.6)						
	---		---	---		0
Tin-man Camp (Rk 84.0)						
	5	3	11	2	7	4
Ruchert's Camp (83.3)						
	2	6	0	0	1	0
Sheep Creek (Rk 80.9)						
	1	0	0	0	0	0
TOTAL # OF REDDS	8	9	11	2	8	25

APPENDIX I.1. *(Cont.)*
Temporal and spatial distribution of spring chinook salmon redds in the Tucannon River, 1990, 1991, and seven year average.

TUCANNON RIVER, 1990

SURVEY DATE: LANDMARK (River kilometer)	8/29	9/5	9/12	9/19	9/26	10/4	10/11	TOTAL
Start of survey (Rk 88.0) – Bear Creek (Rk 86.5)	0	0	0	0	0	0	0	0
Bear Creek (Rk 86.5) – Electro. site # 3 (Rk 84.6)	0	0	0	0	0	0	0	0
Electro. site # 3 (Rk 84.6) – Tin-man Camp (Rk 84.0)	0	0	0	0	0	0	0	0
Tin-man Camp (Rk 84.0) – Ruchert's Camp (83.3)	0	0	0	0	0	0	0	0
Ruchert's Camp (83.3) – Panjab Creek (Rk 76.0)	1	5	11	2	0	0	0	20
Panjab Creek (Rk 76.0) – Marengo (Rk 35.0)	NA	NA	Peak	NA	NA	NA	NA	160
TOTAL # OF REDDS	NA	NA	NA	NA	NA	NA	NA	180

TUCANNON RIVER, 1991

SURVEYDATE: LANDMARK (River kilometer)	8128	9/3	9/10	9/17	9/24	10/1	TOTAL
Start of survey (Rk 88.0) – Bear Creek (Rk 86.61	0	0	0	0	0	0	0
Bear Creek (Rk 86.61 – Electro. site # 3 (Rk 84.6)	0	0	0	0	0	0	0
Electro. site # 3 (Rk 84.6) – Tin-man Camp (Rk 84.0)	0	0	0	0	0	0	0
Tin-man Camp (Rk 84.0) – Ruchert's Camp (83.3)	0	0	0	0	0	0	0
Ruchert's Camp (83.3) – Panjab Creek (Rk 76.0)	1	2	0	0	0	0	3
Panjab Creek (Rk 76.0) – Marengo (Rk 35.0)	NA	NA	NA	PEAK	NA	NA	87
TOTAL # OF REDDS	NA'	NA	NA	NA	NA	NA	90

APPENDIX 1.1. (Cont.)

Temporal and spatial distribution of spring chinook salmon redds in the Tucannon River, 1990, 1991, and seven year average.

TUCANNON RIVER 7 YEAR AVERAGE

SURVEY DATE: LANDMARK (Riverkilometer)	1985	1986	1987	1988	1989	1990	1991	AVG.
Start of survey (Rk 88.0)								
	0	0	0	0	0	0	0	0
Electro. site # 3 (Rk 84.6)								
	0	0	0	0	0	0	0	0
Tin-man Camp (Rk 84.0)								
	0	0	0	0	0	0	0	0
Ruchert's Camp (83.3)								
	8 3	63	15	18	21	20	3	30
Panjab Creek (Rk 75)								
	NA	683	372	217	178	398	200	341
Marengo (Rk 35).								
TOTAL # OF REDDS	--	736	387	235	200	418	203	371

APPENDIX J

EXPENDITURES, INCLUDING MAJOR PROPERTY PURCHASED DURING FISCAL YEAR 1991

TABLE J.l. Project expenditure8

DESCRIPTION	FIRST YEAR CHARGES
salaries	$19,207.14
Benefits	8253.13
Goods/Services	$2,720.54
Travel	8219.25
Direct Costs	$22,400.06
Indirect Costs (20% of salaries)	$3,841.43
Total cost8	$26,241.49

No major property was purchased during fiscal year 1991.